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The Impact of Educational Robotics on Interest towards Technology Careers
and Technology Skills in Brazilian Primary and Secondary School Students –
a Longitudinal Case Study Approach

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ABSTRACT

The study investigated the development of interest towards technology careers and the development of technology skills stemming from the participation in Educational Robotics (ER) approaches in the Brazilian education context. The main research question which guided the investigation is: to what extent does the participation in ER within educational settings influence young learners' interest in technology careers? The following subsidiary questions were addressed in order to explore the theoretical underpinnings informing the investigation: (1) to what extent does participation in ER within educational settings provide young learners with relevant technological skills?; (2) which learning experiences are more effective nurturing career interest in technology?; (3) to what extent does taking part in ER change students' previously intended career choices?; (4) what kinds of barriers and supports have been found during the study and how they interacted facilitating or hindering career interest?; and (5) does the participation in ER within educational settings play a role in young learners' development of a broader vision of the labour market?

The research design was informed by a longitudinal qualitative case study approach. Three educational settings (Primary and Secondary Schools that implemented full-time education using ER approaches) were part of the investigation. Online journals, analysis of documents (including ER curricula and ER projects developed by the participants), semi-structured interviews with young learners, teachers and volunteers, participant observation and researcher's field notes were used as data gathering methods to understand better the phenomenon. Analysis was conducted using the Social Cognitive Career Theory (SCCT) as the theoretical framework used to understand the process of development of participants' interest towards technology careers. The findings revealed that almost all the participants developed such career and/or academic interest towards technology to a certain extent. Notably, the teachers' role as a determinant factor in helping nurture interest towards technology is discussed. Contextual factors capable of blocking and supporting the development of career interest towards technology in the Brazilian education context are also examined. Study findings were aligned with previous investigations that indicated limitations in terms of learning and attitudinal changes depending on the type of ER approach used.

The present study contributes to the existing literature on the impact of ER on career interest in technology and the development of technology skills by investigating the notions of self-efficacy, outcome expectations, choice goals and interests which are being nurtured by Brazilian educational settings offering ER afterschool activities. This thesis recommends the review of ER curricula to help minimise barriers in the development of interest towards technology careers. It also recommends the adoption of multi-approach curricula by educational settings interested in developing educational robotics activities (afterschool or curriculum-integrated). It also proposes a classification to the degree of career interest developed as a result of the participation in ER approaches based on the specificities of the Brazilian education context and inspired by the SCCT.

The study was able to provide an in-depth view of the extent to which interest towards technology was developed in young learners from the three case studies. Future research is necessary to address the long-term impact of educational robotics in career decisions after Secondary School students have graduated. It is also recommended that surveys are used in different Brazilian States to understand regional differences in factors of support and barriers that might affect the development of career interest towards technology. New studies that could encompass the specific factors contributing to the development of interest towards technology would contribute to the research on the field.

RESUMO

O presente estudo investiga o desenvolvimento do interesse em carreiras tecnológicas e habilidades tecnológicas a partir da participação de abordagens de Robótica Educacional (RE) no contexto brasileiro. A principal questão norteadora que guiou esta investigação foi a seguinte: até que ponto a participação em RE, dentro de contextos educacionais, influencia o interesse em carreiras nas áreas tecnológicas por parte dos jovens estudantes? As seguintes questões secundárias também foram relevantes para explorar os construtos teóricos que informaram a investigação: (1) até que ponto a participação em RE, dentro de contextos educacionais, proporciona os jovens estudantes com habilidades tecnológicas?; (2) quais experiências de aprendizado são mais eficazes em estimular o interesse em carreiras tecnológicas?; (3) até que ponto a participação em RE influencia a decisão dos estudantes em considerar uma carreira tecnológica?; (4) quais tipos de obstáculos e suportes foram encontrados durante o estudo e como eles interagem com o desenvolvimento de interesse relacionado à tecnologia, dificultando ou facilitando o interesse em uma carreira na área?; e (5) a participação em RE amplia os prospectos profissionais de jovens estudantes no mercado de trabalho?

Esta pesquisa foi informada pela abordagem de estudo de caso qualitativo longitudinal. Três contextos educacionais de Ensino Fundamental e Médio que implementaram educação de tempo integral usando abordagens de RE serviram de contextos para esta investigação. Os seguintes métodos foram utilizados para a coleta de dado: (a) diários online (Blogs); (b) análise de documentos; (c) entrevistas semiestruturadas com jovens estudantes, professores e voluntários; (d) observação participativa; e (e) diário de bordo. A Teoria Social Cognitiva de Carreira (TSCC) foi usada como quadro teórico no qual o processo de análise foi baseado para entender o processo de desenvolvimento do interesse dos participantes em carreiras tecnológicas. Os achados revelaram que aproximadamente todos os participantes desenvolveram interesse em carreiras tecnológicas de alguma forma. O papel dos professores como um fator que estimulou o interesse em tecnologia é discutido, bem como os fatores contextuais que são capazes de interromper ou encorajar tal interesse. Tais achados estão de acordo com aqueles de estudos prévios que indicaram limitações em relação ao aprendizado e às mudanças atitudinais dependendo da abordagem de RE selecionada.

O presente estudo contribui com a literatura existente sobre o impacto da RE no interesse em carreiras tecnológicas e no desenvolvimento de habilidades tecnológicas a partir da investigação de noções de (a) autoeficácia; (b) expectativas de resultados; e (c) objetivos e interesses de escolha que são estimulados em contextos educacionais brasileiros onde RE é oferecida como uma atividade em turno inverso. Esta tese recomenda a revisão de currículos de RE para que barreiras no desenvolvimento de interesse em carreiras tecnológicas sejam minimizadas. O uso de currículos de abordagens múltiplas é

sugerido para os contextos educacionais onde atividades de RE são desenvolvidas (seja no turno inverso ou integradas ao currículo regular). Uma classificação, baseada em especificidades contextuais e na TSCC, é proposta para identificar o nível de interesse em carreira que pode resultar da participação em abordagens de RE.

O estudo foi capaz de oferecer uma visão aprofundada da extensão do desenvolvimento de interesse em tecnologia nos jovens estudantes que participaram dos três estudos de caso. Estudos futuros são necessários para investigar questões relacionadas ao impacto a longo prazo da RE nas decisões acerca de carreira de estudantes do Ensino Médio. Recomenda-se, também, o uso de questionários para que se possa entender o impacto das diferenças regionais entre os estados brasileiros no desenvolvimento de interesse em carreiras tecnológicas. Novos estudos incluindo fatores específicos que contribuam para o desenvolvimento de interesse em tecnologia contribuiriam para esse campo de pesquisa.

DECLARATION

I declare that the work presented in this document is the original work of the author and that it has not been submitted for any other degree or professional qualification.

A handwritten signature in blue ink, appearing to read 'Eder Coelho Paula', is positioned above the printed name.

Eder Coelho Paula

Date: 08/04/2019

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Starting and finishing a PhD is, to me, a collective effort. The student has to become a better researcher, although that is only possible with the important help from others. Certainly, this is not different from life itself and its inherent tasks, duties and chores; however, it certainly helped me to grow professionally and made me more interested in the field of digital technologies in Education. Those moments of professional, intellectual and personal growth would not have been the same without having the fantastic human beings with whom I shared this path.

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ACRONYMS

CASVE	Communication, Analysis, Synthesis, Valuing and Execution
CEEE	Companhia Estadual de Energia Elétrica (State Company of Electric Power Distribution)
CESMAR	Centro Social Marista (Marist Social Centre)
CIP	Cognitive Information Processing
CRC	Computer Reconditioning Course
EMEF	Escola Municipal de Ensino Fundamental (Municipal Primary School)
ENEM	Exame Nacional de Ensino Médio (National Secondary Education Examination)
ER	Educational Robotics
FASC	Fundação de Assistência Social e Cidadania (Foundation for Social Assistance and Citizenship)
FECI	Fundação de Educação e Cultura do Sport Club Internacional (Sport Club Internacional Education and Culture Foundation)
FIRST	For Inspiration and Recognition of Science and Technology Foundation
FLL	First LEGO® League
FNDE	Fundo Nacional de Desenvolvimento da Educação (National Fund for Educational Development)
FRC	First Robotics Challenge
FTC	First Tech Challenge
FUNDEB	Fundo de Manutenção e Desenvolvimento da Educação Básica e de Valorização dos Profissionais da Educação (Fund for Maintenance and Development of Basic Education and Educational Professionals Valorisation)

FUNDEF	Fundo de Manutenção e Desenvolvimento do Ensino Fundamental e de Valorização do Magistério (Fund for Maintenance and Development of Basic Education and Teaching Valorisation)
GDP	Gross Domestic Product
GRG	Goodman Research Group
ICT	Information and Communication Technologies
INAF	Indicador de Alfabetismo Funcional (Functional Literacy Index)
IDEB	Índice de Desenvolvimento da Educação Básica (Development Index for Basic Education)
MCI	My Classroom Inventory
MIT	Massachusetts Institute of Technology
MOSTRATEC	Mostra Internacional de Ciência e Tecnologia (International Science and Technology Fair)
MNR	Mostra Nacional de Robótica (National Robotics Fair)
OBR	Olimpíadas Brasileira de Robótica (Brazilian Robotics Olympiad)
OECD	Organisation for Economic Co-operation and Development
PCN	Parâmetros Curriculares Nacionais (National Curriculum Guidelines)
PDF	Portable Document Format
PEAC	Programa Escola Aberta para Cidadania (Open School for Citizenship Programme)
PEC	Person-Environment-Correspondence
PISA	Programme for International Student Assessment
PJA	Programa Jovem Aprendiz (Young Apprentice Programme)
PME	Programa Mais Educação (More Education Programme)
PNE	Plano Nacional de Educação (National Plan for Education)

PPE	Programa Primeiro Emprego (First Job Programme)
PROCEMPA	Companhia de Processamento de Dados do Município de Porto Alegre (Data Processing Company of Porto Alegre)
Pro-EMI	Programa Ensino Médio Inovador (Innovative Secondary School Programme)
ProUni	Programa Universidade para Todos (University for All Programme)
RIASEC	Realistic, Investigative, Artistic, Social, Enterprising and Conventional
RS	Rio Grande do Sul
SASE	Sociedade de Assistência Social e Educacional (Society for Educational and Social Assistance)
SATT	Student Attitudes Toward Technology
SENAC	Serviço Nacional de Aprendizagem Comercial (National Service for Commercial Apprenticeship)
SENAI	Serviço Nacional de Aprendizagem Industrial (National Service for Industrial Apprenticeship)
SENAR	Serviço Nacional de Aprendizagem Rural (National Service for Rural Apprenticeship)
SENAT	Serviço Nacional de Aprendizagem do Transporte (National Service for Transportation Apprenticeship)
SIR	Sala de Integração e Recursos (Integration and Resources Room)
Sisu	Sistema de Seleção Unificada (Unified Selection System)
STEBI	Science Teaching Efficacy Belief Instrument
STEM	Science, Technology, Engineering and Mathematics
TIMSS	Trends in International Mathematics and Science Study

TOSRA	Test of Science-Related Attitudes
TWA	Theory of Work Adjustment
VoIP	Voice over Internet Protocol

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CHAPTER 1 INTRODUCTION

1.1. Background

This study investigates the impact of Educational Robotics (ER) in the development of interest towards technology careers in Brazilian Primary and Secondary school students in the context of the implementation of full-time schooling curricula. Since 2007, the Brazilian Federal Government has been implementing full-time schooling within Basic Education, directly funding Primary and Secondary school through educational programmes. The goal is to increase the amount of time that children spend in school from four to seven hours a day and address national educational challenges such as illiteracy. From 2009 to 2013, as the ER advisor for the Board of Education in Alvorada, I had the opportunity to participate in a project which developed, implemented and assessed ER afterschool groups in 24 Primary schools as part of the effort to implement full-time schooling curricula in that city.

During that period, I worked both as a project coordinator and researcher. As such, I helped in the development of, respectively, ER curricula and research focused on the impact of such activities in attitudes and skills towards technology in Primary school students. The results of those research projects evidenced that there had been a difference between what some ER developers' studies had claimed about the advantages of the ER activities and their impact on attitudinal and learning changes. For example, limited evidence could be found that ER had an impact on the learners' interest towards technology careers. Our local findings indicated, however, that ER curricula had an impact on the development of technology skills and interest towards technology – a field that has been in high demand in Brazil. That set of professional experiences inspired me to continue and expand my initial inquiries that started in 2010 by developing this doctoral study project.

1.2. What is educational robotics? Limitations and current issues regarding the definition of ER as a field

ER has been frequently considered a part of the macro-field of the educational technologies (Bernstein, 2010; Jung and Won, 2018). Although robots have been used in education at least since the 1960s (Papert, 1981), its popularisation started after the release of the first programmable robotics kits by Lego® in 1998 (Alimisis,

2013). Since then, research about the topic increased, shedding light over several aspects of the field (e.g.: the cognitive impacts on learners deriving from its practice) (Cotabish *et al.*, 2013; Nugent *et al.*, 2011; Williams *et al.*, 2007). Nevertheless, there is no consensus about the definition of what ER as a field of study is in comparison to other similar terms used in the literature, for example, “robots in education”. In general, it can be said that ER or robotics in education are activities with similar characteristics, such as being underpinned by pedagogical theories in which the central role of the learning process lies on the student (Alimisis and Kynigos, 2009). It is also commonly assumed that ER involves planning, developing and programming robots which usually are built from robotics kits, (e.g.: Lego®, Vex®) (Martin *et al.*, 2000; Üçgöl, 2013). However, can we consider the use of any robots in education (even virtual ones) as an experience included as part of the ER field or is there a difference found in literature regarding such field classification? As previously said, it seems too early to say there is a consensus about the topic in the field or even a general concern about it, although certain authors, as we will see, already started to address the importance of this topic. What follows is a review of how main literature has been defining ER as a field. The limitations of such definitions recently brought by some authors will also be addressed. A definition of ER is also offered in the end of this section considering the same review previously mentioned.

To Eguchi, ER “is a unique learning tool that creates a learning environment that attracts and keeps students interested and motivated with hands-on, fun learning” (Eguchi, 2010b, p.4006). Such definition has been found in many seminal works in the field (Harrison, Report and Harrison, 2012; Nugent *et al.*, 2014; Staszowski and Bers, 2005). It implies that robotics used as a learning tool in education involves a positively interactive learning process (“hands-on, fun learning”), although the aspects of it are not clearly defined *per se* (e.g.: what types of robots are part of it?; or, what is the role of everyone/everything involved in the process?). Another definition is given by Maxinez *et al.* (2012), who stated that ER “focuses on a set of pedagogical activities that develop in the student cognitive skills, through the construction and programming of robots, manufactured and designed to handle in a didactic way” (p. 55). In their definition, specific characteristics of what ER can be are given by the specification of the learning process steps involved in those activities (specific pedagogical activities utilizing robots in a didactic way in order to learn something). Additionally, these previously mentioned investigators seemed

frequently to connect the use of the term “educational robotics” to a set of specific circumstances, as for instance the use of simple block illustrated programming languages and building parts made from plastic. This latter characteristic, however, seems to exclude activities developed from open-source materials (e.g. Eguchi, 2012; Balkenius *et al.*, 2013; Mill and César, 2009; Ribeiro, Barone and Mizusaki, 2015), particularly recyclable robots, which begs, the question: should we exclude activities using robots in education as not being ER? Why?

Addressing that issue, Stergiopoulou, Maria Karatrantou, Anthi Panagiotakopoulos, (2017) stated:

“Educational robotics is the process during which, students having at their disposal small robotic systems, they should assemble and program them to perform certain behaviour for educational purposes. Therefore, educational robotics from a Pedagogical perspective is considered to be grounded in the theories of classic constructivism and in particular that of the constructionism. The learning environment provides activities imbedded in problem solving procedures and, thus, learners build more effective knowledge as they are involved actively in the design and construction (manual and digital) of real objects that have meaning for them in a more natural way” (p. 100).

Here, their definition implies not only a specific type of learning process (activities involving building and programming robotics systems underpinned by constructivism), but they also develop a general idea of what the activities in ER should be and its goals (problem-solving through building intelligent objects). They do not define the types of ER kits (for instance: are they open-source robotics kits?), although it is possible to infer they are talking about physical ones, not virtual robots. Such definition implies that an ER activity must have, as a result, the development of a (physical) robot.

To Angel-Fernandez and Vincze (2018):

“Educational Robotics is a field of study that aims to improve learning experience of people through the creation, implementation, improvement and validation of pedagogical activities, tools (e.g. guidelines and templates) and technologies, where robots play an active role and pedagogical methods inform each decision” (p. 41).

The importance of describing the pedagogic methodologies, learning outcomes and the types of activities when one is conducting a research about ER are addressed in the definition above. The reason for that resides in the identification of an overlapping process regarding the definition of the ER field and others, like artificial intelligence and human-computer interaction. According to them, this has been happening, to date, due to the evolution of new advanced robotics kits used in education, between other reasons.

Notably, all definitions of ER reviewed so far seemed to focus on the role that this technology plays in the learning process (e.g. Alimisis, 2013; Eguchi, 2010) or are seen as a more complex didactic process underpinned by certain pedagogical theories (i.e. constructivism) that aim to develop knowledge through different robotics kits (e.g. Angel-Fernandez and Vincze, 2018; Stergiopoulou, Maria Karatrantou, Anthi Panagiotakopoulos, 2017).

Mubin *et al.* (2013), however, provided us with an overview of the field of robotics that seems to encompass all the aspects involving ER as a field and an activity. By doing that, it is possible that they might help future researchers to address the problem of defining what ER as a field is by indicating what are its limitations. According to them, it is possible to understand the scope of what ER has been by delimiting five criteria: 1) the subjects of the learning activities related to ER; 2) the places where ER takes place; 3) the role and behaviour that robots have during learning and; 4) what types of robots are used in education; 5) the pedagogical theories underpinning the use of robots in education (Mubin et al., 2013, p.2). That means that ER is, firstly, associated with two main subjects: a) technical education (the knowledge one needs to operate a robot – robotics and computer science) and; b) non-technical education (e.g. science, language, etc.). Secondly, ER has been implemented as a learning activity in a variety of educational settings, including intra and extra-curricular locations (meaning that ER can potentially be implemented in any place one is interested in developing it). Thirdly, there are, currently, at least three main roles that a robot can perform during an educational activity: as a tool, as a peer and as a tutor. This is important because the latter two roles do not necessarily involve an active role from the learner as designers and programmers. They seem, therefore, more related to the human-computer interaction field, not the ER one. Fourthly, the types of robots used will vary in each educational setting according to

several factors (costs, training, learners' ages, complexity of programming language, etc.). Nevertheless, some robotics kits (e.g. Lego® Technic – an exclusive mechanical robotics kit lacking the programming option) will not allow certain functions, while others will (a Lego® Mindstorms EV3, for instance, is fully programmable). Finally, it seems that the pedagogical theories from Piaget (1954) and (Papert, 1993) are the most prevalent paradigms underpinning ER activities to date. However, it is possible that other theories could also be seen as underpinning ER activities, included the notion of scaffolding from Vygotsky (1978).

So far, definitions of ER were here reviewed in order to highlight, firstly, the existence of the field at least since 1998, and, secondly, how authors have not yet achieved a consensus of the delimitations of the concept of ER (e.g. Alimisis, 2013; Angel-Fernandez and Vincze, 2018; Eguchi, 2010; Stergiopoulou, Maria Karatrantou, Anthi Panagiotakopoulos, 2017). Therefore, the following definition of ER is proposed considering the literature on the field to date. The intention with that is to contribute with the ongoing debate about the topic through summarising all the aspects related to the development of ER as a field (Mubin et al., 2013). Therefore:

ER is an area of study that was envisioned to help in the learning process of a variety of academic subjects (for example STEM, but also Geography, Electronics and others) and skills (among which solving, research, creativity, etc.) through designing, building and programming physical robots. ER activities have been usually underpinned by pedagogical theories centred in the protagonism of learners, particularly the constructivism and constructionism, although not only them. Such activities usually involve the engagement of learners in a certain type of pedagogical approach namely the project-based one, which incentivises them to research, develop, build and present answers for real-world problems through robotics. However, the ER field can be considered open to the adoption of many other pedagogical approaches. It also seems open to everyone in our society, although it has been frequently developed with students from Primary School to undergraduate courses.

According to Angel-Fernandez and Vincze (2018), it might be necessary in the near future to define the limitations of the ER field and other similar fields of knowledge, as for example human-computer interaction. It is important to highlight that the

delimitation of what types of robots and programming languages can be encompassed as part of ER have not been thoroughly addressed by the literature on ER and seem to deserve more attention by future researchers. The reasons for that include a current great variety of robotics kits, which include mechanical ones that are not programmable (Simões et al., 2013), robots that are used in education but are pre-programmed (Chang et al., 2010), and others. Hence the question: would all types of robotics kits (Lego®, Vex®, open-source ones, Arduino, etc.) or robots be considered as part of the ER field? Literature previously reviewed indicated that the focus of the learning process in ER is the student, therefore, they play a central role in such process (Gaudiello and Zibetti, 2016). We could infer by that premise that robots or robotics kits playing an active role on the learning process should not be suitable for ER activities (Stergiopoulou, Maria Karatrantou, Anthi Panagiotakopoulos, 2017). A practical example is found in the use of robots that play the role of tutors or peers in education (Mubin et al., 2013). These robots, when pre-programmed, for instance for a language class, play a protagonist role in the learning process. That is the opposite role advocated by the definitions of ER (e.g. Alimisis, 2013; Eguchi, 2010a). Regarding the programming languages used in ER, it seems that its use varies according to factors such as learners' ages, interests and teachers/tutor's education (e.g. Gaudiello and Zibetti, 2016; Mubin *et al.*, 2013). Therefore, it is expected that the older learners are, it should be easier for them to use more sophisticated programming languages since they are more capable to develop abstract thinking (e.g. Piaget, 1954; Wadsworth, 1996). Nevertheless, it seems that delimiting programming languages as part of ER is a topic reserved for future researchers to address, since it does not seem to pledge as much controversies than other topics in the field.

1.3. Robotics promoting the development of skills and interest towards technology

Robotics have been used as digital educational technologies at least since the sixties (Papert, 1981), when the LOGO Turtle was used, amongst other purposes, to practice mathematics and robot programming. Since the release of the first Lego Mindstorms kits in the end of the nineties, robotics has been increasingly used as a digital educational tool (Üçgöl, 2013). Reasons for that include the immense versatility of its use in activities of different disciplines (see Physics, Mathematics,

Languages) and its hands-on features (Alimisis, 2013; Eguchi, 2014). Researchers became especially interested in the educational potential of such new learning tool and studies have been developed ever since (Catlin and Woollard, 2014).

Schools have been particularly interested in the potential impact of ER in the development of STEM skills since the beginning of the new millennia, when international agencies identified the need to implement increasingly ICT in the Basic Education curricula worldwide (OECD, 2002, 2007). Eguchi (2009) argues that ER activities can be divided, according to their learning goals, into (a) classes; (b) projects; and (c) competitions. Nonetheless, the research about the development of technology skills stemming from participating in ER activities is still a field that needs developing (Alimisis, 2013). Study findings from other STEM activities (e.g. ICT workshops, Science fairs, ICT tutoring) have indicated that ER could impact on technology skills (see Olsen, Prenzel and Martin, 2011; Potvin and Hasni, 2014).

To date, the evidence suggests that the development of technology skills stemming from the participation in ER activities depends on the implementation approach. Notably, there seems to be a connection between the type of ER approach that is implemented within an educational setting and the impact on the development of technology skills (see Eguchi, 2015; Nugent, Barker and Grandgenett, 2008). For example, evidence suggests that ER classes and projects could impact positively on the development of technology skills (Duran et al., 2014; Nugent, Barker and Grandgenett, 2014), although the same cannot be said about ER competitions. Thus, the study of educational settings implementing all the three ER approaches (classes, projects and competitions) can be valuable to understand this phenomenon. This is especially important when the inquiry focuses on the factors underpinning the development of such skills, as it is the case in this research study.

The development of career interest has been considered a process that occurs through life and might start very early in life (see Hartung, Porfeli and Vondracek, 2005; Vondracek, Ford and Porfeli, 2014). It is also suggested that there is a relationship between being successful performing an activity and the development of interest towards the same activity (Brown, 2002). For example, when one performs an activity repeatedly well, personal positive self-efficacy beliefs tend to raise (Lent et al., 2002). As a result, self-efficacy tends to lead to interest, which tends to lead to goals in the same areas of knowledge in which one is successful. Career interest

system theorists (e.g. Lent, Brown and Hackett, 1994; Vondracek et al., 2014) tend to see the development of interest as a dynamic process. Both, external factors (e.g. lack of learning opportunities) and internal factors (e.g. gender or disabilities) can act as factors of barrier and support in the career choice process.

At least since the last decade, researchers have been suggesting that learning opportunities could influence the development of academic and career interest towards STEM (e.g. Elam, Donham and Solomon, 2012; Qidwai, Riley and El-Sayed, 2013). Understanding which ER activities successfully nurture interest towards technology could be essential for national economies worldwide, since the negative impact that the shortage of workforce can have in industries dependents on these professionals (La Bella, 2014; Kahler and Valentine, 2011). With the increasing number of Brazilian Primary and Secondary schools implementing full-time schooling curricula with ER approaches, it appeared to be necessary to investigate whether the ER approaches have been impacting the interest towards technology careers. Furthermore, students from educational settings situated in underprivileged urban neighbourhoods could benefit from such field by overcoming poverty through their studies and work. Craig (2014) and Duran et al. (2014) propose that ER classes, projects and competitions could influence positively the development of interest towards technology careers. Nugent et al. (2014), however, proposes that only ER competitions (and not ER projects or classes) can impact interest towards engineering, the E in STEM.

Brazilian educational settings implementing full-time schooling curricula offer learning opportunities that, potentially, can help Primary and Secondary school students to develop technology skills and interest towards technology through ER approaches. Hence, this study was developed to investigate the extent to which career interest occurred stemming from ER approaches developed within such educational settings.

1.4. Research Questions

This study is informed by theoretical underpinnings related to: (1) the development of academic and career interest in young learners; and (2) the development of technology skills. The main research questions of this thesis are:

Main research question: To what extent does participation in Educational Robotics within educational settings influence young learners' interest in technology careers?

In order to explore the factors informed by the theoretical underpinnings that could mediate the development of interest towards technology, the following subsidiary questions were addressed:

Sub-question 1.1: To what extent does participation in Educational Robotics within educational settings provide young learners with relevant technological skills?

Sub-question 1.2: Which learning experiences are more effective nurturing career interest in technology?

Sub-question 1.3: To what extent does taking part in Educational Robotics change students' previously intended career choices?

Sub-question 1.4: What kinds of barriers and supports have been found during the study? How did they interact facilitating or hindering career interest?

Sub-question 1.5: Does the participation in Educational Robotics within educational settings play a role in young learners' development of a broader vision of the labour market?

In order to answer these questions, this inquiry was informed by the Social Cognitive Career Theory – or SCCT (Lent et al., 2002). Two educational settings (one developing ER activities at the Primary school level and the other developing ER activities in both Primary and Secondary school levels) were chosen for having implemented full-time schooling curricula. Sixteen participants (6 from Secondary school; 10 from Primary school) were recruited through purposive and homogeneous sampling to participate in this longitudinal multiple case study. Triangulation of data and points of view fostered the recruitment of a group comprising five ER teachers and five tutors. Data was collected through multiple methods, as for instance interviews (semi-structured and focus groups), electronic journals (blogs), observations, document review and researcher's field notes. The main findings revealed that most of the participants developed interest towards technology careers to the point of having developed academic-related and/or career-related goals after long-term periods (between six to eighteen months) performing ER approaches.

1.5. Structure of the Thesis

This thesis is divided into eight chapters starting with the current chapter which offers an introduction to the investigation.

Chapter 2 reviews the pertinent literature in eight main sections. It overviews how robotics has been used in Education for the past two decades offering a definition of ER approaches and discussing the relationship between them and possible learning outcomes. It goes on analysing the development of technology skills stemming from non-ER activities emphasising the role that specific education contexts and curricula play in the process. Next, the usual positive framework of outcomes claimed by educational systems and ER companies is analysed critically and compared to the realistic data found in the literature. What follows is a review of the literature about the attitudinal changes towards technology stemming from ER delineating the more successful approaches to nurturing these changes. It goes on focusing on the development of technology skills as a result of performing ER approaches through short and long-term periods. It is followed by an examination the literature about the impact of ER on interest towards technology careers discussing the role that different approaches, contexts and education levels can play in the process. An overview of the main theories that explain career interest and offers a rationale regarding the use of SCCT as the theoretical framework for this study is then presented. Finally, there is an interweaving of the previous sections and indicates the methodological directions that was explored in this study based on strengths and weaknesses of the reviewed literature.

Chapter 3 presents the context within which this study was conducted and is divided into three main sections. Firstly, the laws governing the Education system in Brazil are presented alongside the role that Federal and regional governments play in Education and the main challenges faced by the country since the democratisation process in 1985. It is followed by an overview of the main socio-economic and educational characteristics of the two settings where this study was undertaken and relates the implementation of full-time schooling curricula to the ER approaches. To sum up, a connection between the previous sections is provided to explain how Brazilian Education is organised by the State and the role that the educational settings play in the process of implementation of full-time schooling.

Chapter 4 outlines the research procedures and the methodological considerations that underpinned the development and implementation of this project and is divided into eight main sections. Firstly, the rationale for the choice of a qualitative approach for this study is provided. The next stage presents the research design used in this inquiry: a case study approach. It is followed by a summary and explanation of the sampling strategies that determined the choice of Primary and Secondary school participants. Next, it outlines and clarifies the strategies used in this study to enhance research quality, namely, reactivity and trustworthiness. An overview of the bounded units of analysis (case study objects) informed by the SCCT model of development of academic and career interest (Lent, Brown and Hackett, 2002) is then provided. What follows is an outline and justification of the methods of data collection used in this study, which involved online and face-to-face interviews, online journals, participant observation, document interrogation and fieldnotes. It goes on addressing the data analysis procedures conducted in this study, which were informed by the SCCT and included precoding, coding and a top-down analysis of the gathered data. Lastly, the ethical considerations regarding clearance, privacy, disclosure, anonymity and translation are the focus of the discussion.

The main findings of this study were separated into three parts, namely Chapters 5, 6 and 7. The study results are informed by the SCCT model of interest, which also oriented their presentation. Those chapters are similarly organised to explain the findings presenting the factors responsible for the development of interest towards technology found in each case study. Thus, each chapter outlines which participants developed academic or career interest towards technology according to a series of factors informed by the SCCT model. Each of the three chapters above indicated are dedicated for one case study. Therefore, Chapter 5 is dedicated to case study 1, and so on. In the end of each chapter, data findings are discussed according to their connections with the development of self-efficacy, outcome expectations, interests, goals and external and internal factors that could mediate the development of interest towards technology careers.

Chapter 8 is the Discussion and Conclusion Chapter and is divided into five main sections. It starts analysing the results of the main and subsidiary research questions and offering a comparison within and across the cases taking into consideration demographics, educational contexts, ER curricula developed and findings. It goes on discussing the methodological and theoretical contributions to knowledge related to

the ER field in the national and international contexts that this study provided. Then, it presents probable theoretical and methodological implications as well as the recommendations for future research taking into account the research design considerations and ethical issues found in this investigation. Next, it considers the limitations of this qualitative longitudinal multiple case study and proposes future research according to the developments of this investigation. Lastly, the conclusion of this study is presented, summarising the main theoretical findings and contributions to knowledge and the relationship between them and the research questions.

CHAPTER 2 LITERATURE REVIEW

2.1. Introduction

For the past two decades, researchers have investigated the impact of ER on learning. A special interest in the use of ER as a tool in learning and the potential of its use to nurture useful STEM skills have guided the field (Alimisis, 2013; Eguchi, 2014; Mubin et al., 2013). To date, studies in the ER field have encompassed a varied range of studies, from the impact of ER as a learning tool to helping the development of social skills in autistic participants to the use of robots in ESL (e.g. Howland and Good, 2015; Robins, 2005). Inquiries about the impact of ER in the development of positive attitudes and interest towards STEM careers have also often been a topic of study (e.g. Eguchi and Reyes, 2008; Griffith Jr, 2005; Lundy, 2007; Whitehead, 2010; Ucgul and Cagiltay, 2014; Wu, 2001). As a result of a decreasing number of STEM workers and undergraduate students who choose STEM-related majors for the past decade (e.g. Gareis *et al.*, 2014; Harrison, Report and Harrison, 2012; Munce and Fraser, 2012; Snyder, 2016), ER approaches started to be seen by researchers as one of the many possible ways to nurture interest towards those fields in Secondary and Primary School students.

This section discusses the most relevant studies about the impact of ER on career interest towards STEM, and, especially, technology and it is divided into six parts. The first part presents an overview of the theories in the vocational psychology field to justify the use of the Social Cognitive Theory as the theoretical framework which underpins this inquiry. An examination of the Social Cognitive Career Theory is presented in order to highlight how its model explains the development of career interest and its intrinsic hypothesis. The second and third parts address specifically the historical claims from robotics companies and education systems regarding the potential that ER curricula seem to have in the development of career interest towards STEM/technology. In so doing, the extent to which such claims are supported by research in the ER field can be understood. The fourth part focuses on the state of the art regarding the impact of ER on career interest towards STEM through the review of the most relevant studies in the area. The fifth part examines the impact of ER on the development of confidence towards technology, which is an aspect that contributed to the development of interest towards technology careers. The sixth part highlights the impact of ER approaches on the development of

technology skills, which is an important aspect on the development of self-efficacy and career interest towards technology.

2.2. Robotics in Education

In the previous chapter, a definition of ER is provided, taking into consideration all the aspects that are part of what ER is as a field and as an activity. ER is a didactical activity (Mubin et al., 2013) , which is a characteristic of the main theories behind ER: the constructivism (Piaget, 1954) and the constructionism (Papert, 1981).

Constructivism is a learning theory created to overcome the belief that learning is a banking process, as Freire (1996) would say, in which teachers deposit knowledge into students' minds, who are the recipient of such knowledge. In the so-called traditional model, teachers have an active role in the learning process, while students have a passive role and knowledge is something that is possible to transmit as it is. In constructivism, instead, Piaget proposes that 'students construct new knowledge from their experiences, through process of accommodation and assimilation' (Eguchi, 2010b, p.4006).

Piaget builds his theory through the notion of schema, which 'are the cognitive or mental structures by which individuals intellectually adapt to and organize the environment' (Wadsworth, 1996, p.14). To Piaget, the process of cognitive and affective development involves the adaptation of previous mental processes schemata in children. Firstly, children tend to use a previous mental process schema to deal with a new information (process of assimilation). In the processes of accommodation, an existing schema is not able to explain a new situation; therefore, the schema changes or a new schema is created in order to deal with that new situation (Wadsworth, 1996).

Constructionism is underpinned by the constructivist idea that learning is a process developed by the learner; although it advocates that such process seems to be more effective when there is more exploring than instructing/teaching involved. It is, thus, a process in which 'learning is driven by the learner' (Eguchi, 2010, p.4007). To Papert (1999), the learning process happens in a more suitable manner when a construct (an idea, a theory, a doubt) can be materialised. In order to do that, it is necessary to provide the appropriate tools for that to happen. Consequently, digital

educational technologies 'give children greater autonomy in exploring larger worlds' (Papert, 1999, p.2).

For instance, when a learner develops a robot to follow a line, we were supposed to perceive that idea in the built robot through its design and program. In both theories, teachers play the role of facilitator providing the needed conditions for the learners develop their self-directed goals, while learners are expected to be actively engaged in the learning process, not isolated from their colleagues and the teacher(s). Both Papert and Piaget also share the idea that students build new knowledge through their own actions and learning experiences, processes during which manipulating objects are fundamental. The difference between the two theories is that Papert's constructionism added the notion that the process of knowledge development happens in an environment where the learner takes part of the process deliberately, regardless whether it is complex task, or a less complex one (Papert, 1981). Eguchi (2010) affirms that, in order to enable successful constructionist learning, ER seems to be a suitable tool, since it provides a way for children to create knowledge through it, while they interact with the educational object as well as the learning environment.

Another pedagogical theory that seems to underpin ER research is social constructivism (Vygotsky, 1978). Vygotsky's theory helped to pave the notion of *scaffolding*, i.e. dividing more difficult tasks in less complex ones (Kozulin et al., 2003). A practical example of the use of scaffolding in this study are the action plans developed by students from all case studies when participating in ER challenges: complex tasks such as moving an object through the challenge map would be divided in steps, which could take months to perfect. Moving the robot to a determinate position in the challenge map would take less steps and time to be developed, since that one could be considered a less complex task.

Robots have been used in education at least since the 1960s with Papert's LOGO Turtle (Mataric, 2004). Its inventors' goals seemed to be an educational tool to which the constructionist theory could be applied by children who were learning how to programme. After the invention of the personal computers in the 1970s and its popularisation in the 1980s, Papert and his Media Lab group from the Massachusetts Institute of Technology (MIT) started a project to expand the capacity of development of the Lego kits by adding the LOGO Turtle programming qualities (Papert and Harel, 1991). In 1998, a product that contained an improved version of the LOGO

programming environment (ROBOLAB) and hardware (Lego Mindstorms RCX) was released in December of that year. Coincidentally, the end of the nineties witnessed a proliferation of personal home computers and the increased implementation of informatics laboratories (Sklar et al., 2000). Miglino, Lund and Cardaci (1999) and Alimisis et al. (2009) suggest that the increased presence of new digital learning technologies in schools helped in their process of adoption and implementation in Primary and Secondary school's curricula worldwide. The first Lego Mindstorms kits contained a programmable brick, motors, sensors, an IR tower, wires and cables, and sensors alongside other accessories which were further released.

In addition to that, its release in 1998 coincided with the start of a STEM initiative called For Inspiration and Recognition of Science and Technology Foundation (FIRST), which intended to celebrate STEM by inspiring young learners to solve real world problems through robotics. Since then, studies about the impact of robotics in education have been often developed (de Vries, 1999; Miglino et al., 1999). Although also known by names like pedagogical robotics and robotics in education, ER has been generally received as the concept to designate this field (see Alimisis *et al.*, 2009; Alimisis, 2012; Eguchi, 2013; Gaudiello and Zibetti, 2016). In order to understand the impact of ER on education to date, several researchers (e.g. Alimisis *et al.*, 2009; Alimisis, 2012; Barker *et al.*, 2012; Eguchi and Reyes, 2008; Holmquist, 2014; Livingstone and Haddon, 2009; Mengoli and Russo, 2014; Miller, Nourbakhsh and Siegwart, 2008; Mubin *et al.*, 2013; Ucgul and Cagiltay, 2014) have undertaken reviews and classifications of such investigations, making it possible for us to provide an overview of the ER field in regards to its impact on Education.

Another important study which helped to shed a light in the characteristics of the research in ER within Education is that of Eguchi (2010). Following other studies (Alimisis, 2013; Gaudiello and Zibetti, 2016b; Mataric, 2004), which also emphasised other possible challenges and the state of the art of ER in Education, Eguchi (2010) was one of the first researchers in the field to propose that specific ER approaches could have specific learning/attitudinal outcomes. In this sense, the author indicates the following three types of approaches that could be applied in ER:

(1) goal-oriented approach (or "tournaments"): this approach gives the opportunity to participants to develop a solution (a "goal") to a real-world problem, which is often miniaturised or presented in a smaller scale. According to the author,

literature to date have indicated general positive learning outcomes (e.g. the development of interest towards Science, teamwork skills, self-confidence, and others);

(2) theme-based curriculum approach (ER lessons during classes): it is based on the integration of ER in the Primary-Secondary School curriculum. Eguchi indicates that this approach seems to be of great help in terms of connecting students' own real-life experiences with learning, as well as a great opportunity to develop problem-solving skills; and

(3) project-based approach: in this approach, students work in teams to develop a project. After finishing it, student present their ER project, outline its function and the method that was used to reach the outcome. To Eguchi, the students can learn about the topics which are related to each specific type of project being developed and develop skills amongst which problem-solving, engineering and programming can be highlighted.

Eguchi's classification became a convention and was used by several other researchers (see Carbonaro, Rex and Chambers, 2004; Kaloti-Hallak, Armoni and Mordechai Moti, 2015; Nugent *et al.*, 2009; Welch and Huffman, 2011; Schiering, Hitzmann and Gerndt, 2014) in order to identify the type of interventions being applied to ER in Education. It also helped to establish the link between the type of interventions being studied and its probable outcome. Hence, if the curriculum is supposedly created with the objective to enhance the development of "teamwork skills", for instance, a project-based approach should be considered the most suitable approach.

The most important systematic review to date relating ER and the Education field is that of Benitti (2012) because it addresses the extent to which the findings presented in the reviewed studies could be considered valid through the application of a series of criteria to analyse the data. The review involved published studies on the use of robotics in schools from 1999 until 2012. The objectives of the study are presented as follows:

- (a) identify the potential contribution of the incorporation of robotics as educational tool in schools; (b) present a synthesis of the available empirical evidence on the educational effectiveness of robotics as an

educational tool in schools; and (c) define future research perspectives concerning educational robotics (Benitti, 2012, p.978).

Benitti's research initially yielded a total of 197 relevant articles, and, after the application of the exclusion criteria, 10 articles were reviewed. The criteria for exclusion included: (a) failure in having robotics as the subject of learning; (b) the absence of quantitative assessment of learning; (c) the lack of robots; and (d) unrelated context (e.g. robotics in contexts other than the Primary and/or Secondary levels). The purpose of the study, the content to be taught with the aid of robotics, the type of robot used and the research method, the sample characteristics (sample size, age range of students and/or level of education) and the observed results of each article were analysed. The findings presented in the reviewed articles suggested that ER usually acts as an element that enhances learning; however, this is not always the case, as there are studies that have reported situations in which there was no improvement in learning.

In Hussain, Lindh and Shukur (2006), two groups of young learners (193 5th grade pupils and 129 9th grade pupils) were assessed in terms of performance enhancement in Mathematics after one year of Lego training. The results indicated that the group with the younger students had better performances in Mathematics after the period of training. The group comprising the older students showed no significant changes regarding their performance in Mathematics. Hussain et al. also found that changes seemed to be focused on learning concepts and skills (e.g. problem-solving).

Benitti's study helped us to understand the impact of ER in Education, pointing out the areas in which there was not significant improvements (e.g. Mathematics in 9th grade, Mathematical and logical problems for young learners with elevated and low scores, Computation, Geospatial concepts, Problem-Solving approaches, skills in performing scientific investigation, socialisation of children with autism, and teamwork). At the same time, it pointed out the areas in which learning enhancement seemed to have significant changes: Mathematics for 5th grade students, Computer Programming, Basic Principles of Evolution, Physics, Thinking Skills, Science Process Skills, Social Interactions of children with autism, Problem-solving approaches. Above all, Benitti's investigation indicated that ER approaches can help in the process of learning STEM concepts, although it cannot be argued that ER as

a tool in learning or as approach is enough to improve or enhance student learning of a specific topic.

In this section, an overview of the impact of ER in Education has been presented. The intention with that was to deepen the debate started in the first chapter about the definition of ER and its use as an educational tool. Then, two studies (Mataric et al., 2007; Eguchi, 2010b) that helped to classify and clarify the different dimensions of the use of ER in Education have been explored. The relationship between types of ER approaches and their possible outcomes has been detailed. Finally, a systematic review of the use of ER as an educational tool in learning has been explored, highlighting the fact that there have been some studies indicating that such tool has not always been effective in terms of enhancing knowledge and developing skills.

2.3. The development of interest towards technology through interventions which are unrelated to ER

ER has been considered as part of the digital technologies used in education that usually provides students with new opportunities for developing skills or to explore different approaches in learning (see Alimisis *et al.*, 2009; Coleman, 2012; Blikstein, 2013). The limits and advances of what has been discovered in terms of the impact of ER approaches on education have been highlighted throughout this thesis. However, one could ask: how different are the outcomes of the inquiries in the ER field related to the development of interest towards technology to those stemming from other types of interventions? And how similar are they? Reflecting upon those questions might clarify whether and how ER approaches can have an impact on interest towards technology. This latter factor is one of the least studied objects within this field; for that reason, this section reviews the existent, yet scarce, literature on the topic. An overview of the similarities and differences between ER approaches and other types of interventions in the technology field is presented.

The most important study to date was organized by Potvin and Hasni (2014) and comprises a systematic review of articles published worldwide regarding the development of Interest (I), Motivation (M) and Attitudes (A) towards Science (S) and Technology (T). The importance of this work is threefold: (1) it is the first review of the theme which encompasses the concepts of interest, motivation and attitudes; (2)

it reviewed studies whose sampling comprised contexts within K-12 levels; and (3) it focused on a considerably long period of time (between 2000-2012). They were interested in the contribution of those articles to the understanding about the process of development of interest towards S&T and how interest towards S&T varies through time.

Potvin and Hasni considered all the articles addressing I/M/A towards S&T in Elementary and Secondary Levels. Six sub-questions guided their review in order to have it focused on (1) the original geographic region of the articles; (2) the categories of the articles; (3) the constructs used to address I/M/A; (4) the main data sources used in each research; (5) what was taught about the relationship between I/M/A and other variables; and (6) what was taught about how to improve I/M/A towards S&T. After the selection and the application of the research criteria, the researchers reviewed 252 articles as part of their study. The results indicated that Summer Camps, Science Fairs and Competitions demonstrated significant improvements of I/M/A towards S&T. Other interventions such as Information and Communication Technologies (ICT), contextualisation, collaborative work, science museums, contact with role models, teacher training, interventions focused on gender-differences and multi-angle programs also indicated positive results for the development of I/M/A towards S&T.

Inquiry – or problem-based learning and hands-on learning – was the only type of intervention which was reported to present no signs of improvement towards I/M/A in 1/3 of the articles. From the seventeen studies which used inquiry as an approach, eleven reported positive results of I/M/A towards S&T. Six of those seventeen articles reported no changes in I/M/A. The reasons for such results were explained by Potvin and Hasni (2014) as follows:

We believe that a rather strong impression that emerges from this review is that most ‘inquiry-based’ or ‘problem-based’ interventions have positive effects on students’ I/M/A, while most ‘hands-on’ activities, which do not require as much reflection, do not (p.85).

The study that was conducted by them strongly indicated a relationship between *development of interest towards S&A* and the *type of intervention* in which the young learner had participated. However, they indicated that there is little or limited knowledge regarding which factors are important in this process. It has also been

highlighted that there is evidence to support the argument that the participants who would probably pursue a career in the S&T fields were not those who had higher I/M/A towards S&T but those who had developed a higher *self-efficacy* towards S&T.

Another valuable study which summarises the research about the development of interest in S&T was conducted by Krapp and Prenzel (2011). Their study focused on explaining the history of interest as a construct in Education, as well as presenting the relationship between development of interest and knowledge contents (e.g. physics and technology). The most significant findings regarding different types of interventions and development of interest towards technology are related to the findings about gender-specific differences within their research. In terms of impact of specific interventions on the development of interest, Krapp and Prenzel (2011) argue that successful programmes aimed to increase young female learners' interest towards S&T through 'suitable tasks and feedback procedures' (p.41).

It is also highlighted that the development of young female learners' interest towards technology might be originated from interventions which change the students' perceptions about technology. Additionally, it is suggested that a temporary separation between girls and boys could increase girls' interest towards technology as well as their self-image. Krapp and Prenzel do not focus on the differences between types of interventions and their impact on interest towards technology; however, in the analysis of how interest varies across schooling and demographics. For instance, it is highlighted that, usually, interest towards S&T decreases with time (especially at the secondary level). School disciplines among which Physics and Chemistry are perceived to play a negative role which contributed to the decreasing process (Krapp and Prenzel, 2011).

Finally, it must be emphasised what the study findings of systematic reviews which were conducted in similar fields in STEM have produced in terms of impact of interventions on interest towards technology. Awan et al. (2011) developed a cross-national review of the development of attitudes towards S&T deriving from multiple different types of interventions – mainly S&T classes. The criteria for the selection of papers included a time frame between 1995 and 2008 during which only studies exploring the main theme were included. Moreover, only those which focused on School population were considered for the final stages of data analysis. Almost 700 articles were found during the first stage when the research criteria were applied.

Study findings indicate that, overall, students from developing countries had more positive attitudes towards S&T than those from developed countries. The TIMSS and PISA¹ also indicated that girls are usually more interested in Biology whereas boys are more interested in Physics. All studies indicated irrelevant gender-related differences in attitudes towards S&T. Gottfried et al. (2017) found that the group of support represented by friends and families also play a meaningful role in the process of development of interest towards Mathematics and Science. According to them, the reviewed literature indicated that the promotion of positive attitudes towards Mathematics and Science by parents can nurture the interest on their children.

This section has presented the development of interest towards technology stemming from educational interventions (courses, small discussion-groups, inquiry, etc.) that are unrelated to ER. Potvin & Hasni (2014) highlighted the fact that most of the studies about the development of interest towards S&T analyse the impact of certain educational approaches on interest. This fact supports the decision of analysing three different educational approaches (ER competitions, classes and projects), in this study, regarding the impact on interest towards technology careers. Krapp & Prenzel (2011) emphasised the importance of activities that are suitable for a specific grade alongside feedback in the development of interest towards science, especially for female students. This finding supports similar study outcomes in the ER field in which long-term interventions (e.g. ER projects) seem to have the potential to influence interest and learning towards STEM (see Cronin et al., 2008; Nugent et al., 2011, 2014). Awan et al. (2011) discussed differences concerning the development of interest towards S&T across nations. Findings indicated that, although interest towards S&T were found in both developed and developing countries, the latter presented higher levels of interest across grades.

It is believed that understanding the specific contexts where ER approaches were developed can help to bridge a way towards career interest and the effective development of career choice goals. The next section addresses the contextual factors which led to the development of this study, focusing on the main claims of robotics companies and national and international education systems.

¹ The Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS) are international tests that assess countries worldwide. A difference between them is that while PISA keeps its focus on how Mathematics can be applied in real life, TIMSS assess a more formal knowledge of that discipline.

2.4. Educational Robotics and the development of career interest according to robotics companies and education systems

Over the last twenty years, ER has frequently been used as an educational tool in hands-on activities both for fun and to help the development of STEM skills and knowledge in education settings (see Alimisis and Kynigos, 2009; Eguchi and Reyes, 2008; Impagliazzo, 2013; Üçgül, 2013; Whitehead, 2010). Several studies worldwide have indicated that ER approaches (e.g. competitions, projects and study groups) could be part of Primary and Secondary School curricula, advocating the educational potentialities of ER (e.g. Barreto et al., 2009; Benitti, 2012; Holmquist, 2014; Hussain et al., 2006; Kandlhofer et al., 2012; Üçgül, 2013). Alongside the claims that ER could be implemented in the Primary and Secondary School curriculum, decision-makers from robotics companies and educational systems have suggested that ER activities developed by them could influence directly career interest towards STEM.

Robotics companies such as the Lego® Company and VEX Robotics have been providing the market with robotics products and curriculum. Those companies, alongside other similar companies, have also suggested that ER approaches (especially competitions) can influence interest towards STEM careers. The same claims have been made by those who have implemented ER in education systems as part of their curriculum. What follows is an overview of those claims that motivated this study in the context of Brazilian education systems which implemented full-time education curricula including ER approaches.

Brandeis (2011) addressed the claims regarding attitudinal changes and learning towards STEM in their executive summary about the educational impact of the FTC (FIRST Tech Challenge) and FRC (FIRST Robotics Challenge), both supported by Lego®. The survey included the teams participating from both programmes in the U.S.A. territory (from 2010 to 2011). Approximately 20% of the teams participating in each programme (1543 FTC teams and FRC 1912 teams) were included in the sample. Almost one third of the sample (30% in FRC and 23% in FTC) comprised female team members. Both programmes presented a similar combination of suburban, rural and urban young people and similar percentages of low-income youth (not identified by the authors). 35% of FTC and 27% in FRC participants were

non-white. Both programmes attracted young people who acknowledged to have had a prior interest in Science, Technology and/or Engineering. Almost 50% of the teams in the sample provided survey responses. Results showed that '80% of team members or more reported that, as a result of FIRST, they wanted to learn more about science and technology, were more interested in science and technology careers, and wanted to be a scientist or engineer' (Brandeis, 2011, p.3).

A similar study (Melchior et al., 2005) intended to assess the long-term impacts of the FTC and FRC on participants who graduated from the programmes between 1999 and 2003. The study indicated that both programmes seemed to have had a positive impact on participants' career choices towards STEM. 156 FRC or FTC participants were part of this study, which was undertaken with school teams from New York City, Michigan and Californian areas. In this study, 41% of the participants were female; 37% came from families where neither parent had attended College; 55% of the respondents were non-white. From the 147 students who provided the information regarding their choices of college majors, 65% of them stated to have chosen STEM-related courses (respectively, Engineering, Business Management and Computer/Information Science). Melchior et al. also emphasised the fact that nearly 60% of the FIRST alumni had at least one technology-related work experience. Those facts and figures seem to evidence, to a certain extent, the development of interest towards the Technology-field demonstrated by FIRST alumni, especially if the impact of that learning experience *after* their participation in FIRST is considered. Nevertheless, further discussion and research are needed so that a better understanding about the development of interest and goals stemming from the impact of the FIRST/FRC in technology-related careers can be achieved.

A similar claim is found in BEST (2013). In this annual report, two outcomes related to career interest and stemming from participating in learning experiences based in the BEST curriculum are suggested: (1) that it was possible to 'experience real-world science and engineering challenges; training that is transferable to all academic disciplines and career pursuits'; and (2) experience 'design-to-market product development – experience that is transferable to all career pursuits' (BEST, 2013, P.10). Both claims, however, did not explain or evidence of the relationship between development of career interest and the adoption of the BEST curriculum. Additionally, it is possible to argue that the "transferability" concept used in the text does not translate the complexity behind a real-life situation which is related to a field like

engineering. In this sense, the conclusions about the potential of the BEST ER curriculum are presented without underpinning them to facts- or data-based arguments.

The study conducted by Cobb (2004) about the impact of BEST on students' learning and attitudes towards STEM shows that, in 2002, interest in 'pursuing a career in engineering increased 25 percent as a result of the programme' (p.19). Nevertheless, the data that was used by Cobb had been gathered by BEST organisers and crucial information, like whether those 25% referred to the total number of participants or just a sample, was lacking. Furthermore, there was no way to compare the participants' pre-existing interest towards engineering to the interest that the participants claimed to have when they were surveyed – which did not help Cobb's argument. The study findings on the LEGO investigations about the development of interest towards STEM careers, however, are consistently underpinned in data, which enhances its validity (Brandeis, 2011; Melchior et al., 2005).

The issue is the commercial use of those positive claims about a product which are not completely underpinned in study findings. As a product, it seems plausible that the purchasing of an ER curricula by an educational setting could depend on factors such as the extent of its impact on students' interest towards STEM careers. And, as it will be further discussed, ER companies have been eager to highlight such these of their products.

Similar claims have been made by both the public and private education sector bodies developing ER activities. In Brazil, for instance, the *PME*² lawmakers state that the goal of ER in the context of the implementation of full-time education is to 'prepare the students to build simple robotics mechanisms using robotics kits, thus enabling the development of engineering skills and robot programming' (MEC, 2013, p.13). Nonetheless, education systems to which those guidelines are supposed to be applied usually have goals and outcomes regarding their programmes that go beyond those guidelines – see Chapters 5 and 6.

² PME refers to the *Programa Mais Educação* ("More Education Programme"). This initiative, which is further explained in the Chapter 3, is a Federal Government programme that funds the development of full-time schooling in Public Schools in Brazil.

Porto Alegre's City Council³, where this study took place, have recurrently related the implementation of their afterschool robotics programme to the outcomes of development of career interest (Ribeiro, 2012). This line of argument was used during the latest election campaign by Bisso (2016) in an article about the participation of one of the schools that participated in the 2015's FIRST competition. According to her, 'the initiative strengthens the capacity of innovation (...) inspiring young students to follow a career on the fields of Engineering, Mathematics and Technology' (p.1). The Marist Network⁴, a private school system, has been developing ER curricula through technology courses in the context of full-time education since 1995. Although the guidelines for the implementation of such programmes inform that the main objective of the initiative is to provide students with meaningful technological experiences, accounts from students indicate how important the programme has been for their professional future/career prospects (R. Marista, 2014). Such statements or claims seem to relate the development of interest towards STEM to the participation in a course within the field of technology. However, studies have shown that the impact of ER on career interest depends on more complex factors than simply one's participation in a robotics workshop or class (e.g. Betz, 2000; Craig, 2014; Griffith Jr, 2005; Nugent et al., 2014).

In this section, claims from robotics companies and education systems which are part of this study have been presented and reviewed. While Lego® has annually presented data indicating that a significant sample of FIRST alumni choose STEM-related majors, other robotics curriculum providers, like BEST and VEX, have not (e.g. BEST, 2013; Melchior et al., 2005; Morrison, 2006; Peckham, 2008; Robinson and Stewardson, 2012; VEX, 2008). More studies are needed in order to confirm the relationship between the impact of ER approaches and development of career interest; moreover, *how* the process of interest happens also needs to be clarified. Statements from education systems that implemented ER in Porto Alegre, where this study was undertaken, connect the participation of students in ER afterschool activities and the development of career interest, knowledge and skills (Marista,

³ PMPA (2015). Novos kits de robótica para alunos da rede municipal. Retrieved 17–4, 2015, from <https://www.youtube.com/watch?v=LcrAzAKAANI>. In this video, professionals and a student, who had been invited by the Porto Alegre City Council, reported their accounts about the new robotics introduced that year. One of the professionals says that, at the ER classes, the results are "immediate", alluding to the development of skills and positive attitudes towards learning through ER approaches.

⁴ A Catholic Education Institute which is further discussed in Chapter 3.

2014; Bisso, 2016). It is necessary to clarify and understand which types of ER approaches have been successful in influencing interest, motivation and/or attitudes towards technology careers and learning. Furthermore, how this process occurs, and which factors seem to be more important need to be understood (Potvin and Hasni, 2014).

In the next section, relevant studies regarding the impact of ER on career interest towards technology are reviewed. The purpose for the review is to discuss limitations of findings regarding the impact of ER on interest towards technology found in the literature to date. Understanding these limitations might clarify whether the claims that have been made by ER companies and Brazilian education systems can be supported by those findings and indicate future research within the field.

2.5. Relevant studies about the impact of robotics on positive attitudes towards technology

Several studies have suggested that the importance of the development of confidence is one of the first steps towards the development of career interest (e.g. Brown, 2002; Griffith Jr, 2005; Patton and McMahon, 2006). Since the popularisation of the implementation process of robotics as a tool in learning, researches have indicated the potential that robotics approaches have in fostering the development of positive attitudes towards STEM (Bers et al., 2013; Holland, 2004; Jewell, 2011; Nugent, Brad Barker, et al., 2009; Whitehead, 2010; Holmquist, 2014). This section brings a review of the studies which sought to investigate this phenomenon as its connections with the different types of ER approaches that are used as well as other variables – as for instance demographics and gender.

One of the first attempts to investigate the impact of ER on positive attitudes towards STEM was the investigation which involved 504 students from South Carolina public Secondary schools (Griffith Jr, 2005). In this quasi-experimental study, the students participated in a six-weeks curriculum which concluded with their participation at the FRC⁵. 131 participants were part of the experimental group (FIRST) and 373

⁵ The FIRST Robotics Competition is a challenge designed for collaboration in teams for Secondary School students. Each year, teams have a period of six week to work on their robot players that could weight around 120 pounds. The theme of the event changes annually and the competition is divided into different stages – including regionals, nationals

participants were part of the control group. Students participating in the control group enrolled in STEM courses in one of the twenty Secondary Schools sponsoring FRC teams. Participants of both groups completed pre/post surveys regarding the development of attitudes and interests in STEM. The experimental group comprised 30% female students and 70% male students amongst whom 29.92% represented some minority group whereas 70.08% represented white participants. The control group comprised 39.70% female students and 60.30% male students amongst whom 33.07% represented minority groups whereas 66.94% represented white participants.

The pre- and post-test survey was the “What Do YOU Think? Survey” designed by the Goodman Research Group (GRG) and used previously by LEGO to investigate the impact of their programs on the development of attitudinal changes and career interest towards STEM. Seven categories of attitudinal outcomes were considered and compared in relation to gender and demographics. Data analysis showed that students in the FRC group had a higher attitude means than students in the control group on both pre- and post-survey regarding the seven attitudinal categories (which included teamwork, Science and Mathematics, Technology, Engineering, and enjoyment of High School Science and Mathematics classes). The study also showed that the participants’ expectations concerning their access to Higher Education changed after participating in the study.

Students who belonged to a minority, within both groups, were less likely to assume that they would go to college than the white students. Interestingly, the female students within the FIRST group stated they were more likely to conclude a 4-years college course than the male participants. The female students within the control group, however, responded to the question in the same way as those participants belonging to the minority groups. The study supports the argument that competitions as an ER approach can impact on the development of interest towards STEM.

The study also indicated a connection between participants’ perceptions on their academic future after the ER competition and their gender and demographics profile. Hence, the study seems to highlight the influence of the contextual background on

and a world challenge in the USA. FIRST, *What is FIRST Robotics Competition?*, <https://www.firstinspires.org/robotics/frc/what-is-first-robotics-competition> (accessed 06/ 01/2017).

the participants' interest and goals towards STEM, despite the development of a positive attitude towards STEM that is indicated by the findings.

Five years later, Nugent et al. (2010) published the results of their study about the impact of robotics interventions on attitudes towards the STEM field. The intention was to investigate the impact of different types of ER interventions on the same attitudes. In this case, a three-hour long intervention was compared to a 40-hour long robotics camp. The sampling comprised 147 Primary School students who had participated in those activities and the control group consisted of 141 Primary School students who had not engaged in ER activities. Pre- and post-test TOSRA (Test of Science-Related Attitudes) surveys were applied. The results indicated that a longer intervention was more likely to impact on learning whereas the shorter intervention had a higher impact on attitudes towards STEM. Both interventions indicated that the students within the sampling group had better results on learning and attitudes towards STEM than those within the control group. The study was important because it was one of the first studies to suggest a difference of impact on attitudes towards STEM stemming from different ER approaches.

Previous studies which were conducted during the past decade indicated that there was limited evidence of the impact on attitudes towards all the disciplines of STEM and stemming from ER approaches (e.g. Batula et al., 2012; Jewell, 2011; Jim, 2010; Melchior et al., 2005). Another example comes from Karp and Maloney (2013), who published the results of their study that tracked 77 Primary schools which implemented an eight-weeks curriculum preparing for the FIRST competition, with the participation of 982 participants between 2011 and 2012. During this period, female students always comprised, at least, 33% of the total of participants (in 2010, 44% of the participants were female). 56% of the participants were male in 2010 and 67% between 2011 and 2012.

The study aimed to evidence the successful implementation of an afterschool robotics programme in Texas. The study also compared the results in terms of gender and ethnicity (Karp and Maloney, 2013, p.46). Using a mix-method approach (qualitative and quantitative), researchers studied the growth and the impact of the programme in Elementary and Middle School students. They were also interested in the impact of the programme in the attitudes towards STEM within the same group of participants. The method that was used to gather data regarding interest towards

STEM was a pre- and post-test survey. The quantitative data about attitudes were analysed through paired sample t-tests. The analysed data indicated, firstly, that the programme was especially helpful in the development of attitudes towards STEM for, non-white Hispanics female participants who indicated that they receive a free lunch in school. A two-paired sample t-test with significant level of 0.05 was applied to all the participants and showed a meaningful increase in the answers of questions related to Robotics (I can fix a programme and programme a robot to follow a line) and Science (I like using a scientific method to solve problems and it is important to collect and interpret data to test the veracity of a hypothesis).

When they compared the results within underrepresented groups, a higher score was obtained by the female participants. Male participants did not show a significant improvement for questions 11, 20 and 21, which suggests a stronger relationship between this group and scientific methods and robotics. Finally, when comparing non-white Hispanic students to white students, a significant growth was observed in participants within the first group for questions 17, 20 and 21 (confidence towards problem analysis using the scientific method). The only change that was considered significant within the group comprising white participants was a decrease in enjoying the process of solving a problem as a group. Overall, Karp and Maloney's study reported a meaningful change in terms of attitudes towards Robotics and Science stemming from an afterschool programme implementing an ER approach (competition). More surprisingly is the effect on underrepresented groups (non-white Hispanic female participants) in comparison to white participants.

Ka & Jim (2010) developed a study that investigated students' and teachers' perceptions on their classes, their attitudes towards robotics and effects on motivation through a robotics programme integrated to the Science, Mathematics and English curricula. For 15 days, 204 6th graders alongside 14 teachers within three different magnet schools from Texas participated in the study. A mixed-method approached was used to gather data about their perceptions on the classes and development of attitudes and motivation towards STEM. Qualitative methods, such as interviews, observations and note-taking, were used to understand the process of implementation of the programme and its impact on the participants. The quantitative methods used were (1) the Test of Science-Related Attitude Elementary – second version (TOSRA2); (2) My Classroom Inventory (MCI) short form; and (3) the Science Teaching Efficacy Belief Instrument (STEBI).

The programme comprised a series of 15 interactions, each one having a 90-minutes robotics class. During the programme, after every five meetings, teachers organised a robotics competition so that the students presented a solution for a problem proposed by the organisers. Students would also have to present the technical aspects of their choices for programming, engineering, aesthetics, etc. Data regarding the development of attitudes towards Science were provided by TOSRA2. Although the effect size of the study had been usually below 0.3, findings comparing the difference between pre- and post-tests showed decreased results. For instance, the results for students' enjoyment of Science lessons and adoption of scientific attitudes significantly decreased (respectively, from 2.60 to 2.38 and from 2.58 to 2.30). Interviews with students and teachers evidenced that the factors behind those numbers might have been the following:

- (a) the way that the programme was implemented probably disrupted students' perceptions on Science as discipline and Science classes in general; and
- (b) the fact that the programme was not the same within each school, since the teachers were able to adapt it according to their contexts.

It was interesting to notice the study's attempt to combine robotics and the regular curriculum. Although the experiment did not achieve its goal, it signalled changes that could help the development of new programmes in the future by addressing students and teachers' perceptions.

Jewell (2011) investigated the impact of ER on attitudes towards STEM. This quasi-experiment comprised a sampling of 57 Secondary school students participating in an NXT Robotics curriculum for eight weeks (study group) and a control group with 57 Secondary School students, presenting similar demographics, who participated in a Science class (which did not include robotics) for the same period. The TOSRA survey was the instrument used to gather data about the development of interest and attitudes towards Science through a pre- and post-test. Grade level, ethnicity and gender were used to compare groups, and the survey was used specifically to determinate attitudes related to science inquiry, enjoyment of science lessons, leisure interest in science and career interest in science.

A total of 96 male participants and 18 female participants were part of the study. The ethnic composition of the participants, who declared their own ethnicity, was the

following: white: 47.4%; black: 42.1%; Hispanic: 7%; and Asian: 3.5%. Participants' composition according to their grades were as follows: 9th graders: 33.3%; 10th graders: 19.3%; 11th graders: 33.3%; and 12th graders: 14%. The analysis of data for attitudes related to science inquiry resulted in little positive difference between pre- and post-tests. For enjoyment of science lessons, there was little difference when the comparison criteria were related to gender whereas there was significant difference when the criteria were related to grades and ethnicity. For instance, there was a significant difference in enjoyment of science lessons between 12th and 9th graders, as well as 12th and 10th graders. There was also a significant difference between white, non-Hispanic and black, and non-Hispanic students. Subsequently, data analysed for leisure interest in science demonstrated almost no difference when the criteria were related to grade and gender. However, it showed a significant difference when the criteria were related to ethnicity. The importance of this study lies in the results across-grades which seem to differ from previous studies that indicated that interest towards science would normally decrease with the progression of grades (Awan et al., 2011).

Holland (2004) developed a study with 20 5th grade students (between 10 and 11 years of age), from a magnet school from Ohio, who had been identified as having superior cognitive ability. The students participated in a preparatory activity for the FIRST challenge. The main goal of the study was to investigate the impact of such ER activities in students' attitudes towards technology and technological literacy. Five control groups comprising participants with similar demographics and grades (two regular classes – 4th and 5th grades) and three gifted classes (two with 4th graders and one 5th grader) also participated in the study. For six months, students engaged in problem-based activities (mainly ER classes, group discussions about technology and its role in our society) concluding with a FLL competition. The classroom procedures were aligned with the Standards for Technological Literacy, funded by the National Science Foundation, which defined what students need to know in order to be considered technology literate in the 21st century.

A mixed-method approach was used to gather data for this study. A Likert-type pre-post survey with 22 questions about attitudes and perceptions about technology was developed for the study. Additionally, a Student Attitudes Toward Technology (SATT) was also applied. Students also participated in focus group interviews about robotics, technology and education. Analysed data indicated that all the students participating

in the ER activities developed positive attitudes and perceptions related to interest and value of technology in comparison to participants in the control groups. In terms of gender, female participants demonstrated more positive attitudes and perceptions towards robotics than male participants. The female participants identified themselves as equally capable of participating in technology whereas the male participants realised that technology demanded more abilities than they had initially assumed and perceived less value related to technology.

The ER activities occurred within the technology curriculum implemented by the School. Overall, the study provides evidence of the impact that the inclusion of ER activities in the regular curriculum have on interest towards technology. Furthermore, the ER approach which was used (problem-solving with ER classes concluding with an ER competition) was able to have an attitudinal impact on the group of participants in comparison to the participants within control groups.

Table 2.1 summarises the findings regarding the impact of ER approaches (competitions, classes and projects) on the development of attitudes towards technology.

Table 2.1: Impact of ER on attitudes towards technology

Reference	Key findings & Arguments	Supporting evidence, Sample characteristics & Methods	Strengths & Limitations	Relevance & Implications
Karp, T. & Maloney, P., 2013.	(1) Participants' attitudes towards Science and Robotics increased (no increase verified towards Engineering and Mathematics); (2) Female participants had greater results for interest towards scientific methods and robotics than male participants; (3) Non-white Hispanic students had significant results against white-students in confidence towards problem-solving using scientific methods.	(1) 982 Primary School participants (2011-2012); (2) 33-44% female participants and 56-66% male participants; (3) Mix-method approach (survey and interviews) was used to investigate the influence of ER Competition on interest towards STEM; (4) Lego Mindstorms kits were used in the study.	(1) Great variety of response rate (56% to 88% depending on the cases); (2) Study was not able to follow-up individual cases in order to verify if interest was able to be translated in academic goals towards science and robotics.	(1) Support the claims that ER competitions can influence interest towards science and robotics (technology); (2) Point out to gender and ethnics differences in the development of interest towards science and robotics in the sample (females and non-white Hispanics had bigger scores in interest than white participants).

Ka, C. & Jim, W., 2010.	(1) No significant changes in students' attitudes towards Science after the 15-days programme; (2) Difference in the pre and post-tests revealed decreased results in terms of development of interest towards science.	(1) A mix-method approach was used in the study; (2) In total, during the 15-days programme, 204 6th grade students and teachers from three different Magnet Schools participated in the study; (3) Each interaction involved a 90-minutes meeting (ER classes and competitions); (4) Lego Mindstorms kits were used in the study.	(1) The Program varied for each School; (2) Each science teacher could develop their own curriculum according to each school science curriculum.	(1) Results support the claims that ER classes and competitions used in conjunction were not able to impact on interest towards science; (2) Results support the claim that the way the ER curriculum was implemented in the three magnet schools had a negative impact on students' interest towards science (integration through implementation of ER as a tool in learning).
Jewell, S.L., 2011.	(1) The data for leisure interest in science showed very little difference by grade level and gender, but a significant difference by ethnicity between the White, non-Hispanic and Black, non-Hispanic students; (2) For comparison across ethnicity, there was a significant difference between the Black, non-Hispanic and the White, non-Hispanic students.	(1) Examined the effects of a quasi-experimental NXT robotics curriculum CLASS on Secondary School students; (2) A group of 57 students participated in a NXT robotics class, and the same number in a science class (comparative study); (3) Students were surveyed to determine changes in leisure interest in science and career interest in science; (4) Results were analysed according to participants' demographics and gender.	(1) Details, such as how many classes happened, involvement with peers were not addressed; (2) Generalisability of the study is limited, since only 9th-12th graders participated in the study.	(1) Study supports claims that ER classes also can influence the development of interest towards science in the so-called minority groups; (2) The study also points out to heterogenic differences in development of interest towards science stemming from ER classes by grade.
Holland, S.M., 2004.	(1) All participants stated to have developed more positive attitudes and perceptions related to interest in and value of technology compared to students without these activities; (2) Girls also displayed more positive attitudes and perceptions related to robotics.	(1) Sample constituted of 20 5th grade students having superior cognitive ability. The treatment group had 9 girls and 11 boys. Five other control groups with similar demographics participated in the study; (2) Interventions involved 6 months of problem-based activities (ER classes, and ER competitions); (3) A mixed-method approach to gather data (survey, interviews, observations and note-taking) was used for this study; (4) Lego DACTA gear sets were used in the study.	(1) The study was able to include a specific group (gifted and talented) without these activities; (2) The scope of the study was reduced.	It adds evidence to the impact of the inclusion of ER activities in the regular curriculum on interest towards technology.
Griffith Jr, D.S., 2005.	(1) Participants in the experiment developed higher attitude means towards STEM than the ones from the control group; (2) Minority groups declared that they were less likely to expect a 4-years college degree than white participants; (3) Female participants declared that they were more likely to expect a 4-year college degree than male participants.	(1) Quasi-experimental study (participation in a 6-weeks ER curriculum); (2) A pre-post survey encompassing the development of interest towards STEM after FRC; (3) 504 participants (131 from the experiment group and 373 from the control group); (4) Lego Mindstorms kits were used by the teams; (5) Gender and ethnicity were variables used to compare the results between groups.	(1) The study was not designed to follow up the translation of interest in goals or interest in the participants; (2) The study was not able to point out which factors in the ER curriculum seemed to have helped the participants to develop interest in STEM; (3) The study offered comparison between groups in terms of gender and ethnicity.	(1) It supports the claims that ER competitions can influence the development of interest towards STEM; (2) It also highlights the importance of the contextual background influencing students' perceptions about their future careers and academic interests.
Nugent, G. et al., 2010.	(1) Long-term interventions are more effective in impacting on learning STEM; (2) Short-term interventions are more effective in impacting on interest towards STEM; (3) Students from the treatment group had better results both on learning and attitudes towards STEM than those in the control group.	(1) Pre-post application of the TOSRA survey; (2) 147 Primary School students participating in the ER interventions and 141 participating in STEM activities that were not related to ER; (3) Aimed to investigate the impact of different short-term and long-term ER activities; (4) Lego Mindstorms kits alongside GPS receivers and the ArcMap software were used in the study.	(1) There are no indications about the factors related to ER behind the development of interest towards STEM; (2) The study highlights the potential of ER afterschool interventions as benefiting both learning and positive attitudinal changes.	(1) The study substantiates the claims that there is a difference in the impact of short-term and long-term ER activities; (2) It also supports the claims that ER camps (classes) are able to impact on learning STEM and attitudes towards STEM (ER short-term classes)

This section has reviewed the literature about the impact of ER approaches on the development of attitudinal changes towards STEM – specifically technology. Two

studies indicated that ER was able to impact on positive attitudes towards technology when the ER approaches used were ER competitions and classes (Holland 2004; Karp & Maloney 2013). Findings revealed that competitions were able to influence on attitudes towards technology stemming from the participation in ER competitions. There is also evidence of the impact of ER on positive attitudinal changes towards technology stemming from ER classes (Nugent et al., 2010).

Concerning the ER approach used, not many studies have investigated the impact of ER on attitudes towards technology stemming from ER projects as the main approach. Limited evidence of the impact of ER classes as the main approach has been provided (Nugent et al., 2010). However, studies have evidenced that ER can impact on attitudes towards technology stemming from studies using competitions as the main ER approach (see Griffith Jr, 2005; Holland, 2004). Additionally, four of the studies discussed previously showed that development of interest towards science and technologies increased when the criteria were related to gender and ethnicity (Griffith Jr, 2005; Holland, 2004; Jewell, 2011; Karp & Maloney, 2013). Jewell (2011) emphasised difference in the development of interest towards science when the criteria were related to grade, which was the opposite of the trend found by Olsen et al. (2011) whose study indicated a decrease of interest towards science. Findings from the study conducted by Karp & Maloney's (2013) showed no increase in interest towards STEM; however, there was a decrease in interest after the implementation of a robotics curriculum integrated to the science curriculum of the schools participating in the study. Overall, the literature about the development of interest towards technology lacked studies about the impact that ER projects as approach can have on such interest. Two ER approaches (competitions and classes) have been discussed in terms of their success in helping to increase interest towards technology. The next section addresses the main studies about the impact of ER on technology skills.

2.6. Relevant studies about the impact of robotics on technology skills

The need for development of actions which could help governments and educational systems to overcome the current deficit of STEM workers has been addressed by

several studies (e.g. Bakke, 2013; Duran et al., 2015; Harrison et al., 2012; Lehming et al., 2010; Munce and Fraser, 2012). STEM skills are a set of abilities that can be developed through activities such as robotics performances and which are related to the Science, Engineering, Technology and Mathematics fields. Programmes for educational systems have been developed in order to enable students from Primary and Secondary schools to learn how to work in groups, apply content, be involved with inquiry, communicate and engage in STEM subjects (e.g. Bevan et al., 2010; Duran et al., 2015; Ebelt, 2012; Holmquist, 2014; Kanematsu and M. Barry, 2016; Koumoullou, 2013). One method which has been used to promote the advancement of technology skills is the development of ER approaches from Primary School to the tertiary level (ACM, 2013; Tatnall & Davey 2014). This section focuses on learning rather than attitudinal changes, as the previous section. In so doing, this section reviews the most relevant studies about the impact of ER on the development of technology skills.

Nugent et al. (2010) and Nugent et al. (2014) seemed to be, to date, the most significant studies about the impact of ER on the development of technology skills because both studies considered the differences between ER approaches. Nugent et al. (2014) intended to investigate the impact of multiple cases represented by robotics camps, clubs and competitions which took place between 2009 and 2012 with the participation of more than 5000 youth and 400 teachers. A sampling group comprising 1825 campers, 458 competition participants and 126 club participants provided data during a period of six, three and two years, respectively. A multiple-choice testing was developed for camps and clubs covering STEM knowledge, attitudinal change and career interest. The assessment that was applied to the competition participants was similar but shorter due to time constraints which is a characteristic of this ER approach.

The instrument's Cronbach alpha reliability was consistently around 0.82. The sampling group consistently comprised 70% of male participants and 30% of female participants. Results showed that the findings within the camps were the most stable, although all three ER approaches – clubs, camps and competitions – revealed comparatively high effect sizes for the knowledge outcomes (mainly programming and engineering). The effect sizes for programming, at some point, achieved 0.70 for Camps, 0.96 for Clubs, and 0.40 for Competitions. The analysis of individual scale

scores showed that the results were driven by the growth of knowledge about engineering and programming.

Nugent et al. (2010) evidenced the existence of an impact of ER on technology skills. The study was designed to be a comparison study between longer ER interventions (ER robotics camps with a 40-hours curriculum) and shorter ER interventions (3-hours workshop). 147 students participated in the camps/workshop groups and 141 students participated in the control groups. A 37-item multiple-choice testing was used pre- and post-test which covered Mathematics, Geospatial concepts, Engineering, and computer programming. Results showed that the camps' participants increased their STEM learning (programming, mathematics, geospatial technologies and engineering) more than the participants in the shorter workshops and control group. Hence, for the STEM skills results, camps (with ER classes) were an ER approach that was able to nurture them, while competitions, short interventions and clubs did not have the same significant results in terms of impact on technology skills (programming).

Another important aspect taken in consideration when reviewing the literature about ER is the presence or lack of longitudinal studies. Since the latest studies have indicated that the impact of ER on STEM learning is more effective in longer than shorter interventions (e.g. Nugent et al., 2008, 2010, 2014), it can be argued that more studies focusing on this aspect are needed. One of the most significant studies about the impact of ER on STEM learning was published by Duran et al. (2014). This 18-weeks long study comprised 77 Michigan Secondary School underprivileged students who were part of afterschool IT/STEM activities. The sampling group was divided in two cohorts who participated in ER activities which took place between 2009 and 2011. A 23-item survey rating their skills on a 0-4 points scale (0= I do not use and 4= Expert). The ER approaches used were the development of projects and classes. From the 23 items on the survey, 20 showed a statistically significant positive change from pre- to post-test within both cohorts. There were no statistically meaningful changes between cohorts. Findings indicated that the impact of the programme on students' IT/STEM skills was significant (technology skills, such as using computers, programming and use of database software). The study was also important because it addressed the impact of a curriculum which had the goal of nurturing IT/STEM skills in a longer range of time and in an underprivileged area.

Bernstein (2010) aimed to investigate the impact on technological fluency that robotics workshops using mixed ER approaches (projects and classes) might provide. The Robot Diaries workshop was an enrichment programme which was used as an educational context for this investigation. Seven female participants between 9 and 14 years of age participated in this study which consisted of a 16-hours curriculum with robotics/technology classes that would generate robotics projects. A qualitative approach for the study was used with triangulation of methods (students' pre, mid and post interviews and journals) and triangulation of perspectives (students', teachers' and parents'). Results showed that, despite the post-interventions attitudinal changes, changes in technology skills were limited. These results seem to be in consonance with previous studies within the ER field which indicated that short interventions have more chances to impact on attitudinal changes than on contents of learning (Nugent et al., 2010, 2014).

In this section, the most significant studies about the impact of ER on development of technology skills in Primary and Secondary school students have been reviewed. Although there has been evidence that ER projects and classes can impact on the development of technology skills (Duran et al. 2014; Nugent et al., 2014), there has been limited evidence that ER competitions (a third different approach) can generate a similar outcome. It has been argued that more longitudinal studies to investigate the relationship between ER activities and the impact on development of technology skills are needed, since there has been limited research about the outcomes of ER programmes using mixed ER approaches (Bernstein, 2010). The lack of investigations on the impact of technology skills stemming from the implementation of a mixed ER approach curriculum within this specific context – Primary and Secondary school located in underprivileged areas – motivated the development of this study. Additionally, because studies have evidenced that longer interventions are more likely to influence the development of STEM learning, a longitudinal approach was used for the research design.

2.7. Educational robotics and the impact on career interest towards technology

Studies have shown that certain economic sectors, such as those related to the STEM field, have been suffering with the lack of specialised workers (Harrison, 2012; Lehming et al., 2010). According to ManpowerGroup (2015) there has been a surplus

of STEM workers in the academic sector in the U.S.A., whereas the government and government-related sectors have been suffering from shortages within specific areas – such as Nuclear Engineering and Electrical Engineering. They also indicate that Brazil is one of the five countries where employers have more difficulties in filling positions in its workforce alongside Japan, Peru, Hong Kong and Romania. More than 20.000 employers from 42 countries around the world participated in a study which investigated the shortage and reasons for shortage of talents worldwide. The private sector ‘also has specific shortages for positions such as petroleum engineers, data scientists and software developers’ (Xue and Larson, 2015, p.1).

The positions that companies have more difficulty to fill are related to the Engineering field (Mechanical, Electrical, Mechatronics), IT (especially programmers, developers, database administrators, leaders and managers) and Automation (technicians and engineers). Conversely, countries such as Czech Republic, Netherlands, Spain, the UK and the Republic of Ireland differ completely from Brazil, since they represent the group of five countries where employers have less difficulty in finding specialised workers within the same fields previously mentioned. Resende et al. (2013) argues that, in Brazil, it is challenging for employers to find such specialised workers within the technology field. Amongst other issues that contribute to such shortage, companies’ representatives claim that the lack of professional expertise and misaligned salary expectations are the main reasons for unfilled job positions.

There seems to be a difficulty, worldwide, in recruiting post-secondary students to study STEM-related college courses. For instance, in the U.S.A., an annual report elaborated by the Department of Education regarding the students who study within STEM-related areas showed that the number decreased more than 10% between 1995 and 2004 (Chen, 2009). In a more recent study, Munce (2012) suggested that, although the number of High School students interested in STEM have had an increase of 20%, the issue is related to the increasing gender-gap. 14.9% of female students had expressed interest in STEM whereas 39.6% of male students within the same country had claimed to be interested in such fields. In Brazil, both educational and economic sectors have experienced similar issues (e.g. Oliveira, 2014; Resende et al., 2013; Resende & Sousa, 2014). The difference is that, in Brazil, the number of matriculations in STEM-related Post-Secondary courses has risen due to an increase in the number of new Universities and Undergraduate courses available (MEC, 2014; Oliveira, 2014). It seems, however, that due to the economic barriers, such as lack

of family support and need to work in order to support their studies, the issues within the Brazilian context is the social-gap (MEC, 2014).

This section further reviews the relevant studies about the impact of ER on Primary and Secondary School students' career interest towards technology fields. Aspects such as ER approaches used, educational contexts and research design are used in the analysis. Studies about the impact of ER on career interest tend to focus on a single approach (e.g. goal-based, project-based or theme-based) during a specific period/non-longitudinal (see Craig, 2014; Holland, 2004; Kandlhofer et al., 2012). Vocational psychology researchers have demonstrated the importance of factors such as interest and attitudes towards STEM in the development of career interest in STEM-related topics (see Athanasou and Van Esbroeck, 2008; Brown, 2002; Vondracek et al., 2014). Despite being a topic which has been little researched for the past decade, studies about the impact of robotics on career interest towards technology have demonstrated the potential of ER approaches to nurture interest towards STEM.

Nugent et al. (2014) address this issue. Their organisation – Gear Teach 21 – developed a 40-hours ER curriculum for afterschool clubs and camps (for competitions, their model of curriculum is an adaptation of FLL⁶). 5000 young students (67% male and 33% female participants), whose economic status was not disclosed, were part of the research. The study investigated mainly (a) the impact of different ER approaches (clubs, camps and competitions) in the development of STEM skills; and (b) the impact of these three ER approaches in the development of career interest towards STEM. The instrument used to evaluate interest in certain STEM-related careers utilised Likert-format ranging from (1) very uninterested to (5) very interested. Small sized effects were those ≥ 0.20 ; medium sized effects were those ≥ 0.50 ; and large sized effects were those ≥ 0.80 . The research design used throughout the project was repeated measures, pre- and post-design, with dependent “t” tests examining differences between means at the two-time points. More than 5000 participants, comprising learners from 23 states of the U.S.A., were assessed.

⁶ FLL – First Lego League is a worldwide robotics challenge developed by FIRST LEGO® aimed to develop skills, knowledge and interest towards STEM for students from 9 to 14 years of age. Students have to develop solutions (building robots and writing a paper) within a specific topic, which changes every year, such as the importance of water, environment, importance of nature, etc.

Data regarding the career interest generate the findings which are presented in Table 2.2.

Table 2.2: Findings of Nugent et al. (2014, p.15)

	Camp					Club		Competition		
Outcome	'09	'10	'11	'12	'13	11-12	12-13	'10	'11	'12
Cognitive: Overall	.60	.72	.51	—*	—	.58	.69	.28	.06	—
Programming	.40	.70	.45	.43	—	.50	.96	.40	.09	—
Engineering	.44	.60	.62	.49	.43	.39	.59	.14	.09	—
Math	.49	.12	.05	.28	—	.01	.06	—	—	—
Eng. Design	—	—	—	.16	.17	.34	.16	—	—	—
Science	—	—	—	—	.11	—	.25	—	—	—
Task Value										
Science	.15	.10	.20	.14	—	.01	-.09	.20	-.02	.13
Math	.02	.03	.14	.30	—	-.08	-.08	.17	.06	.17
Robotics	-.11	-.06	.16	.38	—	-.05	-.05	-.02	-.11	.12
Robotics Self-efficacy	.57	.33	.37	.40	—	.04	.36	.22	-.02	.18
Workplace										
Teamwork	-.47	.03	.13	.05	—	-.02	-.02	.00	.11	.38
Problem Approach	.12	.31	.25	.19	—	-.04	-.04	.30	.17	.43
Career										
Scientist	.05	.04	.14	.08	.16	.05	-.20	-.06	-.02	.08
Engineer	.11	.13	.20	.01	.09	.08	-.25	-.08	.16	.21
Mathematician	-.08	.18	.13	.08	.17	.10	-.16	.06	.15	.11
Technologist	.09	.01	.11	-.01	.13	-.07	-.41	-.02	-.19	.07

*Data not available

Career interest findings indicated that the camp data are more positive for an engineering career; however, there were only two occurrences (2011 for Camps and 2012 for Competitions), which resulted in “small” effect sizes, as presented in Table 2.2. Club data did not show any increase in youth interest in pursuing STEM careers. The study also did not indicate the participants’ career interests (if any, and, if they were related or unrelated to STEM) before participating in the study. There was no follow-up study about the career interest in STEM stemming from the participation in clubs, camps and competitions. Robotics camps (using ER classes and projects), clubs (using the same approaches as camps) and/or on the competitions (ER challenges) were not able to impact on career interest towards technology.

Craig (2014) study about the relationship between ER and the development of career interest towards technology aimed to ‘understand how robotics programmes influenced young women’s career decisions and the programme’s effect on engineering, physics and computer science career interests’ (p.3). Participants for the sampling group were selected amongst volunteers from the FIRST Robotics

Competition and contacted by the researcher via *Yahoo Chat* and by emailing FRC organisers. Craig justifies the development of a Grounded Theory by arguing that such approach enables an in-depth study about the influence on career choice. Listening to the voices of the young women revisiting their experiences more than eight years after the original events, Craig expected to understand the reasons why those women had chosen their careers and the role played by their “heroes” in that choosing process.

Nonetheless, the study presents limitations and generalisation, since a group of only 10 young female volunteers from California were part of the sampling group. Regardless, Craig claims that the study can be replicated in other areas which present similar challenges, for instance, in competitions promoted by robotics companies such as VEX, Best or SeaPerch. The findings supported that the participation in an FRC team helped young female students who had already been interested in STEM careers before Secondary School to strength the decision of continuing in this vocational pathway. Young female students who had not chosen a STEM-related career before Secondary School, despite having participated in the FRC, revealed that the preparation for the competition and the role models (coaches, family and heroes) helped to shape their career interest and, ultimately, helped them to become who they are.

The study is important for (a) identifying the moments in life when the young female students decided to follow a STEM-related vocational after their participation in the FRC; and (b) explaining the impact of important factors, such as role models, in their decisions. However, the size of the sampling group (only 10 female professionals) limits the generalisation of the findings and more studies are necessary to confirm the contribution of role models (“heroes”) to young female students’ career interest towards STEM. Regardless, this study can be considered a retrospective one, which, according to Miller and Salkind (2002), might be disadvantageous because it relies on what participants recall and due to the risk of possible bias. The study findings also revealed that the ER challenges (FIRST and FRC) had been indicated as educational contexts that helped participants to nurture interest towards engineering and technology. Nevertheless, all participants stated having been interested in STEM-related professions before their participation in ER challenges, limiting the extent of the impact on career interest towards technology.

Duran et al. (2014) investigated attitudinal and learning changes towards IT/STEM stemming from the participation in an ER afterschool programme. 77 Secondary school students, who were divided into two groups, participated in this study from 2009 to 2011. The study was developed in the School District located in South-eastern Michigan. The participants belonged to underserved populations, were students with special needs and/or female (Duran et al., 2014). No further demographic details about the participants were given (such as number of males/female participants, economic status, etc.). Students were invited to participate in an 18-months course (150 hours) related to IT/STEM (including robotics and programming) as afterschool activities, including classes, development of projects and externships. A combination of quantitative and qualitative methods was used to collect data from the pre- and post-surveys, analysis of the participants' IT/STEM projects, external evaluation reports and follow-up interviews. Results suggested that participants had 'fairly strong aspiration for a career that uses a lot of technology' (Duran et al., 2014, p.120). 55% of the participants indicated an increase or sustained interest towards IT/STEM fields. It is important to highlight that the results did not support the argument that the ER approach developed during the study had been able to impact on career interest towards technology, despite the importance attributed to the use of technology for the participants' career choosing process.

The studies reviewed in this section have not indicated any development of career interest towards technology on participants from Secondary and Primary School. Table 2.3 presents a summary of the findings regarding this matter.

Table 2.3: Summary of ER approaches studied and verified impact on career interest towards technology

Study	ER approaches studied	Research Design	Impact on career interest towards technology
Nugent et al. (2014)	ER competitions (FLL curriculum); ER as a tool in learning (classes): camps and clubs; ER projects: clubs	Pre- and post-survey tests Longitudinal study	Lack of impact in all ER approaches
Craig (2014)	ER competitions	Qualitative study (focus group interviews); grounded theory-based	There was an influence on career interest towards Technology stemming from the preparation for the FRC and some role models
Duran et al. (2015)	ER classes ER projects	Mixed-method approach (pre- and post-surveys, document analysis and interviews) Longitudinal study	More than half of the participants indicated an increase or sustained interest towards IT/STEM careers

While the findings presented in Craig (2014) and in Duran et al. (2014) indicated that all the ER approaches (projects, competitions and classes) can potentially impact on the interest towards technology careers, the findings in Nugent et al. (2014) did not. Probable reasons for that include the differences in the variables between the first two studies and the latter. Nugent et al. (2014) present the application of a curriculum for a 40-hours period whereas Craig's and Duran's studies are based on a longer period (hundreds of hours). Nugent et al. (2010), however, had already emphasised the relationship between long-term interventions (just as those found in afterschool ER projects in Brazil) and the positive development of interest towards STEM. For that reason, the next section addresses the relationship between ER and the development of positive attitudes towards technology, a factor that, according to vocational psychologists, can also help the development of career interest. Furthermore, the next section examines the most important career choice theories, indicating reasons why SCCT, rather than others, was chosen as the theoretical framework for this study.

2.8. Review of Traditional Career Development Models and Choice within the Social Cognitive Career Theory

Vocational psychologists have been trying to understand the phenomenon of how people choose their careers and how career interest develops over time since the beginning of the 20th Century (Vondracek et al. 2014). In order to understand whether ER could possibly influence the development of career interest towards technology in young learners, a theoretical framework needed to be chosen. The following three factors were key for the selection of an adequate career choice theory for this inquiry:

- (1) the need of including the impact of learning experiences as part of the process of career interest development (since the investigation is about the development of career interest as a result of ER approaches);
- (2) a career theory able to encompass the inclusion of young learners as subjects of the study who are capable to develop interest towards careers in technology; and
- (3) the need to test consistently and thoroughly the constructs on which the theory is based and the theory itself (providing enhanced validity).

This section reviews six career development theories in order to assess their adequacy to inform this study. The first four theories which are discussed are the following: (1) Dawis' Theory of Work Adjustment; (2) Holland's Typology Theory; (3) Self-Concept Theory of Super/Savickas; and (4) Gottfredson's Theory of Circumscription and Compromise. Because none of those four theories were considered adequate to inform the development of this inquiry, two other learning-based career theories were assessed: (5) Social Cognitive Career Theory (SCCT) (Lent et al. 1994); and (6) Brown's (2002) Cognitive Information Processing Approach to Career Problem Solving and Decision Making. The last part of this section presents a justification for the selection of SCCT as the theoretical framework on which this inquiry was based.

2.8.1. Theory of Work Adjustment

The Theory of Work Adjustment (TWA) is based on the person-environment correspondence theory, which defines career interest and development as a result of an accommodation and adjustment process (Dawis and Lofquist, 1984; Rounds et al., 1987). In this dialogic process, a person (P) searches for an environment (E) that matches his/her prerequisites in terms of needs, while E, in turn, looks for individuals who are capable to meet the requirements of a certain organisation (Athanasou & Van Esbroeck 2008). Satisfaction is the term used to indicate the degree which P is satisfied with E, and satisfactoriness is the equivalent term used for E in relation to P. For P, the most important requirements to be met from E are his/her needs whereas for E, the most relevant requirements needed from P are abilities or dimensions of skills that P possesses and are necessary in E. According to Brown (2002), the extent of P's satisfaction and E's satisfactoriness would cooperatively predict tenure in that work environment.

Overall, TWA has a good support for the core of its prepositions, although some of them, such as Brown's (2002) argument that 'the probability of P leaving E is inversely related to P's perseverance' (p.454), have been limitedly tested (Athanasou & Van Esbroeck 2008). According to Brown et al. (2005), this limited testing is a result of the tendency, which started in the middle of the 1980s, to apply the Person-Environment Correspondence (PEC) theory in real life as a guiding framework for a vocational assessment clinic providing career counselling to adults. Athanasou and Van Esbroeck (2008) argue that TWA aims to 'explain career development and

satisfaction in terms of person-environment correspondence'; moreover, TWA provides career guidance professionals with a 'template to locate entry points to assist individuals with career choice and adjustment concerns' (2008, p.134).

For the past decade, researchers have employed TWA in research with groups of immigrants (e.g Eggerth and Flynn, 2012; Ghasemzadeh et al., 2010; Lyons et al., 2014) multicultural groups (Lyons et al., 2005) and testing the validity of TWA's prepositions (Brown, 2002; Feinberg, 2009). However, despite its importance within the vocational psychology field as framework, TWA presents limitations such as the rather "static" view of its variables E and P, which have been progressively become more dynamic (Bayl-Smith and Griffin, 2015). Furthermore, vocational psychologists criticise the notion that person-environment correspondence is achieved when the responses of P and E are satisfied (Vondracek et al., 2014). Holland and Nichols (1964) expanded this notion by demonstrating how people and contexts could be classified into a combination of different types. Hence, Dawis and Lofquist's theory did not address important factors such as the influence of learning experiences, socio-structural barriers or personal factors to explain the development of career interest.

2.8.2. Holland's Typology Theory

According to Athanasou and Van Esbroeck (2008), Holland's theory has provided an important framework for vocational counselling and guidance. Holland (1997) suggests that there is a relationship between one's personality and one's vocational interest. According to him, those types of vocational interest could be Realistic (R), Investigative (I), Artistic (A), Social (S), Enterprising (E), and Conventional (C), or RIASEC. In this sense, there is the possibility to evaluate the similarity of six vocational personalities and interest types and one's resemblance to them in order to develop a three-letter code (SIA, RIA, for instance) to indicate one's career interest. The first letter of the code is one's primary interest type whereas the other two are one's secondary types.

Since it was published, Holland's theory has been tested in order to determine the accuracy of its prepositions and the validity of its instruments (Holland, 1997). Athanasou and Van Esbroeck (2008) argue that the cross-cultural validity of Holland's theory needs to be confirmed. Theorists have recently demonstrated that,

due to their limitations, the Holland's theory frameworks cannot fully explain the development of career interest based on the relationship between environment and one's personality without considering several other factors (such as culture, gender and available opportunities) and variables (such as time and location) (Vondracek et al., 2014).

2.8.3. Self-Concept Theory of Super/Savickas

According to Athanasou and Van Esbroeck (2008), the theory that Super (1990) developed has been well-known by researchers within the vocational psychology field. Super (1990) argued that choosing a career is the result of a development and implementation process of one's self-concept. Self-concept, in this sense, is a product of the relationship between several factors, such as stimulation, environmental features, physical and mental growth and personal experiences. Super (1990) proposed a developmental framework for vocational behaviour comprising the following four stages: growth, establishment, maintenance and disengagement. In each stage, one must perform a set of vocational developmental tasks according to one's age range. According to Super (1990), for example, a person between 15 and 24 years of age is expected to manage the tasks of crystallisation (understanding what one's interests, skills, and values are and pursuing objectives accordingly). The concept of career maturity was proposed by Super and Sverko (1995) in order to indicate the degree of success reached after performing the vocational development tasks. Savickas (1997) suggested that the concept of career maturity should be substituted by the notion of adaptability.

Super's theory seemed to have brought an important contribution to the vocational psychology field when he proposed that career interest should have been perceived as part of a larger and dynamic process that occurs throughout one's life. Athanasou and Van Esbroeck (2008) argued that many aspects of Super's theory, such as life roles, career maturity and developmental stages, were adopted by other researchers. Integrated theories, based on aspects of Super's theory (such as developmental stages and the idea of vocational behaviour), have been developed as well (e.g. Athanasou & Van Esbroeck, 2008; Lent et al., 1994; Porfeli et al., 2011; Vondracek et al., 2014).

Super's theory still seems to need cross-cultural validation and a better understanding of the role played by gender in the development of career interest (Athanasou and Van Esbroeck, 2008; Lau et al., 2013). According to (Vondracek et al. 2014), there are indications that career interest is a process which starts to develop during early childhood and, alongside the influence of learning experiences on career interest, was not addressed in Super's theory.

2.8.4. Gottfredson's Theory of Circumscription and Compromise

Gottfredson's theory (Gottfredson, 1981, 2002) is not as established as the other theories that have been previously reviewed. According to Athanasou and Van Esbroeck (2008), Gottfredson's theory defines career development as a self-creation process in which individuals search for opportunities to express their genetic inclinations within the limits of their own socio-cultural environments. She proposed that career choice and development are processes of circumscription in which one gradually eliminates certain occupational alternatives from consideration. Furthermore, Gottfredson argues that career objectives are less influenced by individual aspects of self-concept (such as interests and skills) than by the public (social class and gender). A developmental model comprising four stages of circumscription was proposed (Gottfredson, 1981). The stages are the following:

- (1) orientation to size and power (from 3 to 5 years of age), which involves the child's understanding that occupations are roles performed by adults;
- (2) orientation to sex roles (from 6 to 8 years of age), which involves the emergence of sex-role norms and attitudes as delineating aspects of a child's self-concept – occupations perceived to be inappropriate for their genders are eliminated;
- (3) orientation to social valuation (from 9 to 13 years of age), which involves the elimination of occupations that are perceived to be too low in terms of prestige or too high considering one's self-efficacy level; and
- (4) orientation to the internal unique self (from 14 years of age on), which involves comparing the remaining options of occupations with the internal aspects of the adolescent, such as interests, skills and values.

Another important aspect of Gottfredson's theory is the notion of compromising. Gottfredson (1981) proposed that one's interest is always committed to favour one's preference for sex-type and prestige as a response to external realities and limitations such as economic depression. Swanson and Blustein (2013) explain that Gottfredson's theory has received limited independent support. Athanasou and Van Esbroeck (2008) highlight that, due to the longitudinal characteristic of Gottfredson's framework, it is quite difficult to assess the validity of the theory in its entirety. Despite the inclusion of social status and gender, Gottfredson's theory seems to be limited in comparison to other theories that incorporate sociocultural influences (Brown, 2002; Lent et al., 2008; Vondracek et al., 2014).

2.8.5. Career Theories Anchored in Learning

SCCT (Lent et al., 1994) and the Cognitive Information Processing Approach to Career Problem Solving and Decision Making (Brown 2002) seem to be more suitable frameworks for researchers who aim to investigate the development of career interest and to work with groups comprising children/adolescents, since these theories are anchored in learning. The next sections address those two theories and review their main propositions in order to justify the selection of SCCT as a theoretical framework for this study.

2.8.5.1. A Cognitive Information Processing Approach to Career Problem Solving and Decision Making

Cognitive Information Processing (CIP) (Brown, 2002; Lea and Leibowitz, 1992; Peterson et al., 1991) is a theoretical approach in career theory which intends to provide help for individuals to become 'skilful career problem solvers and decision makers throughout their lives' (Brown, 2002, p.312). CIP is based on the work of Parsons (1909), one of the first theorists who developed a theory that was established on the cognitive perspective. Parsons proposed three key factors underpinning career choice: (1) self-understanding; (2) knowledge about occupations; and (3) the ability to build relationships from them (Parsons, 1909).

CIP is anchored in learning due to the self-knowledge characteristic of its framework, which has three lines of inquiry for an individual to reach an answer about a career problem: (1) self-knowledge; (2) occupational knowledge; and (3) career-decision

making. The main goal of this model is to assist individuals who want to become career problem solvers through different steps ranging from the 'smallest inner circle, which is the career problem, to the largest encompassing outer circle, which is lifestyle, with each succeeding concept encompassing the previous concept' (Peterson et al., 1991, p.427). CIP developers organised information processing domains as a pyramid with self-knowledge and occupational knowledge as the base. Other information processing skills that are important, when in response to external or internal signals of problem, comprising Communication, Analysis, Synthesis, Valuing, and Execution (CASVE). Those skills are relevant for career problem solving and a range of problems found over one's life (Lea & Leibowitz, 1992). A set of cognitive functions were positioned on the top of the pyramid. Those are responsible for monitoring, guiding and regulating the lower orders of functions 'namely the acquisition, storage and retrieval of information, as well as the execution of cognitive strategies to solve a problem' (Peterson et al., 1991, p.437).

Due to its nature and for empowering individuals searching for self-knowledge, this model has been largely used by counsellors and vocational psychologists. According to Patton and McMahon (2006), 'its ready translation to counselling and programmatic interventions' is one of the acknowledged strengths of this approach (p.127). A recent description of CPI discussed the cultural considerations of the model and its applicability to different populations (Patton and McMahon, 2006).

Developed to be a career guidance framework which helps individuals to develop career solutions, CIP differs from traditional theories in its goals and approaches. However, CIP seemed to fail to comprehend development of career interest which would not stem from an individualistic point of view, despite understanding that the context might be part of the CIP process. CIP is anchored in learning because, through self-knowledge and following a certain set of steps, an individual can tread a path from career problem to change of lifestyle and, therefore, decision-making towards a wanted career choice. This approach also seems to lack further validation through research in different cultures.

2.8.5.2. Social Cognitive Career Theory

According to Lent et al. (2002) SCCT is one of the theories in the vocational psychology field that tried to build a convergence of concepts and methods that can

explain the development of career interest while considering internal and external factors which act upon a more comprehensive model created on the impact of cognitive and learning processes. SCCT is mainly derived from Bandura's social cognitive theory, which stresses the interactions between the self-perception beliefs one has and the influence that society has in terms of influencing comportment (Bandura, 1999).

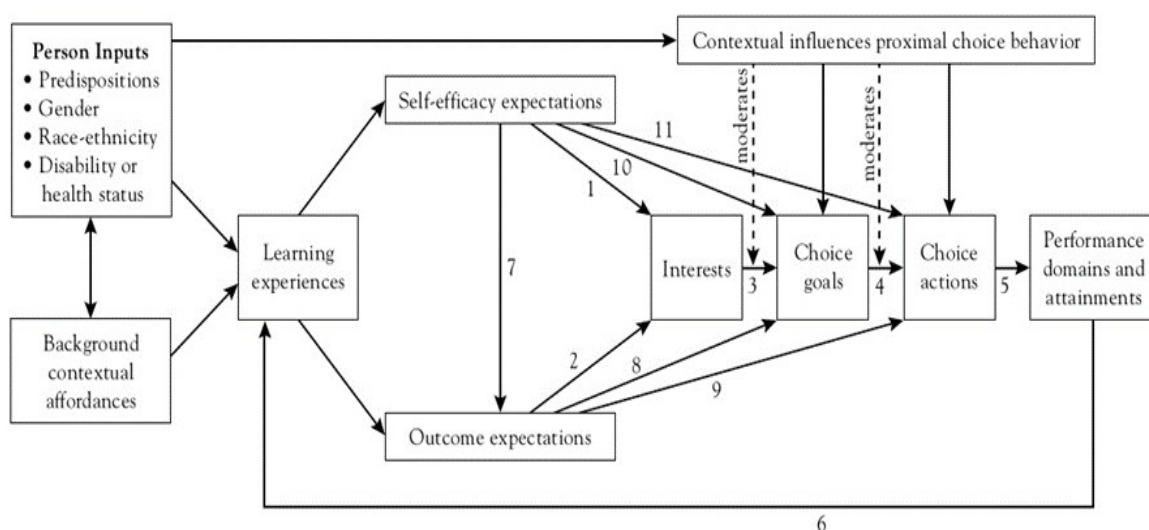
According to the SCCT, three concepts are the foundation that explain career interest over time: (1) self-efficacy; (2) goals; and (3) outcome expectations (Brown, 2002). SCCT focuses on the interplay amongst person, context and personal behaviours that are hypothetically responsible for influencing the process through which people develop career interest, revise it and achieve career pursuit (Lent et al., 2008). Alongside the three key theoretical constructs underpinning SCCT, external and internal factors can also influence each step of the career development process (see Figure 2.1). For instance, it could be expected within the context of this study that students from an at-risk background would be less exposed to learning opportunities that could lead them to develop self-efficacy towards technology than others living in more socially and financially favourable conditions. What follows is an overview of each variable in the SCCT model that could influence one to the development of interest towards a technology career:

- Self-efficacy: instead of being a decontextualized trait, self-efficacy 'involves a dynamic set of self-beliefs that are specific to particular performance domains and that interact in a complex way with other person, behaviour and environmental factors' (Lent et al. 2002, p.262). Self-efficacy can be obtained from several sources, such as personal performance accomplishments, vicarious learning, affective and emotional state and social persuasion, although personal attainments are seen as the most compelling source of self-efficacy (Lent et al., 1994). In the context of this study, learning experiences such as the participation in an ER project or the extended preparation for an ER competition, could, eventually, lead one to develop self-efficacy towards programming, or engineering, problem-solving skills, etc.
- Outcome expectations: they are acquired through learning experiences similar to those that inform self-efficacy and derive from people's appraisal of the outcomes (such as rewards that they might have received for performing relevant actions in the past). Outcome expectations can be also influenced by self-efficacy

when outcomes are determined by the quality of one's performance (Lent et al., 2008). Although environmental events and personal history undoubtedly help in shaping it, behaviour is not entirely determined by the vicissitudes of a nonspecific reinforcement history, by genes, or by other non-volitional factors. It is also partially motivated by people's self-directed goals and other social cognitive factors with which goals interrelate (Lent et al., 2008). It is possible to argue that outcome expectations involve beliefs related to the consequences of performing determinate behaviours, such as 'If I do this, what will happen?' whereas self-efficacy beliefs are related to one's capabilities to perform an activity 'Can I do this?' (Lent et al. 2002, p.262). In the context of this study, many examples of development of outcome expectations have been explored. A symptomatic aspect stems from the participation in ER competitions such as FLL. At a certain point, a group of participants stated having developed outcome expectations beliefs about their capability to improve their robot project due to the opinion and encouragement coming from the judges of the competition (people's appraisal of one's outcomes).

- Goals: according to Lent et al. (1994), goals are an important factor in the development of career interest mainly because they represent an expression of one's self-determination to perform a particular outcome. Hence, goals are defined as the determination to engage in a certain activity or to perform a specific objective. When they involve specific intentions, 'they can also be called plans, choices, or decisions, depending how near one is to the stage of career entry' (Lent et al., 1994, p.45).

Figure 2.1: The SCCT choice and performance model (Lent et al., 2002)



According to the overlapping models of interest and choice (see Figure 2.1), self-efficacy beliefs, outcome expectations and goals act to produce career interest as follows:

- self-efficacy, which are 'beliefs about one's ability to perform successfully particular behaviours or courses of action', stimulates encouraging outcome expectations;
- outcome expectations are 'beliefs about the consequences of giving actions. Students can feel inclined to develop interests (liking for) in topics in which they hold a strong self-efficacy and confident outcome expectations;
- choice goals, or the 'intent to choose or persist at a particular course of action', are understood as a result from self-efficacy, outcome expectations and interests. Goals are also supposedly influenced by the context (e.g. presence or absence of learning opportunities) and the virtual absence of barriers (e.g. presence of learning opportunities). Supports and barriers may 'promote choices indirectly by bolstering or weakening self-efficacy' (Lent et al., 2008, p.53).

2.8.6. Summary of the main career choice theories

Most of the critiques regarding traditional vocational psychology theories that explain the development of career interest are based on the selectivity of one's attributes (such as values, goals, interests) rather than the contextual aspects which might explain such phenomenon (Vondracek et al., 2014). Athanasou & Van Esbroeck (2008) argued that most of the traditional career theories still lack international studies that could validate them. Most of those theories were based on studies developed with male groups and in first world countries (mainly in the U.S.A.), which indicates the need to use a theory that could encompass gender diversity and sociocultural differences as well (Patton & McMahon, 1999).

The absence of data regarding the impact of external factors such as socio-political and sociocultural contexts has been widely criticised (Athanasou & Van Esbroeck, 2008; Brown, 2002). For example, although Gottfredson's theory and Dawis' TWA seem to encompass social context as a major aspect influencing development of career interest, context refers to that with which one has immediate contact. However, SCCT is a framework in which structural barriers and social context

(international-, national- and even regional-related) can influence directly one's career interest.

Another important aspect that has been criticised is the focus on male young adults/adults' perspectives, which can virtually incapacitate its use to analyse groups comprising adolescents, women, immigrants and members of other sociocultural communities (Athanasou & Van Esbroeck, 2008; Brown, 2002; Patton & McMahon, 2006). Gottfredson's theory, for example, encompasses career interest from early childhood (from 3 years of age), whereas Dawis' TWA, Holland's RIASEC and Super's theory comprehend groups of more mature individuals. Regardless, all those theories have helped school counsellors and psychologists to guide the public to develop a better understanding about career interest or career development (Brown, 2002). Such help has been mainly stemmed from frameworks which were based on those theories, such as Holland's RIASEC, which is used by counsellors to build a summary of areas of interest and connect with available educational/work opportunities within their regions. Nevertheless, even in Gottfredson's case, where one's behaviour is expected to be formed at a certain point, the influence of learning experiences on career interest is not part of the framework.

The selection of a theory which could encompass the impact of learning process in the development of career interest (such as CIP and SCCT) seemed to be the best option for this study. Nonetheless, since CIP has been largely used to address individual cases in the process of career choice (Brown, 2002), that model did not seem to be the most appropriate choice to be used in this study. CIP is a theoretical framework to solve individual career problems rather than a framework to understand complex processes regarding the development of career interest during which contextual and individual factors might play a key role.

Mani (2004) argued that SCCT is not an appropriate vocational psychology theory to be used in order to understand career interest throughout someone's life but it is suitable to explore career development in late adolescence or the beginning of childhood. Lent et al. (1994) also state that SCCT could be used as an instrument to understand the development of both career and academic interest. Since this study aims to investigate the extent to which the development of interest towards technology careers stems from robotics approaches in Brazilian Secondary school students, SCCT was highly considered to inform the theoretical framework.

Several researchers (e.g. Athanasou & Van Esbroeck, 2008; Brown, 2002; Patton & McMahon, 2006; Vondracek et al., 2014) have emphasised the validity of SCCT to explain the development of career interest. SCCT is an attempt to develop an integrative framework mainly based on the concept of self-efficacy found in Bandura (1999). SCCT is a theory that combines several aspects of other theories in order to explain the development of career interest or vocational behaviour. According to Lent et al. (2002) 'SCCT was designed to address such questions, to help construct useful conceptual bridges, to identify major variables that may compose a more comprehensive explanatory system, and to sketch central processes linking these variables together' (p.257).

It can be argued that the development of other theories which could be more adequate to the Brazilian contexts might offer a better explanation to the development of career interest stemming from learning experiences (such as the ER approaches) studied in this inquiry. Studies such as Nugent et al. (2015), for example, focused on the U.S.A. contexts and offered a new explanation to the development of career interest stemming from ER by using the same SCCT as theoretical framework. Findings indicated a relationship between the influence of teachers, peers and family and the development of STEM interest; moreover, a connection between the development of self-efficacy and outcome expectancy beliefs has been revealed.

The SCCT model can offer an explanation to the development of career interest because it enables the consideration of important factors (such as individual self-agency), individual backgrounds (such as gender, culture, ethnicity, health status) and contextual affordances. The model also offers an explanation to why contextual influences (such as factors of barrier and support) can moderate the development of interests and goals. Lent et al. (2008) tested the SCCT model as capable of predicting interests and choice goals in the computer-related disciplines. The study involved more than 1000 students from the U.S.A. attending a wide range of computer-related disciplines. Participants completed surveys relating factors such as interests, choice goals, self-efficacy and outcome expectations to their majors. After that study, similar inquiries tested the model across cultures and disciplines. The findings indicated that the SCCT model had predicted adequately the results across the group variables (such as gender and educational levels). Athanasou and Van Esbroeck (2008) argued that SCCT has been able to present a framework that can be used for career guidance consultancy and research due to its testable propositions and hypothesis.

However, adaptations need to be made to the instruments and variables related to SCCT so it could be tested and validated across cultures (Athanasou and Van Esbroeck, 2008).

Other studies seemed to have confirmed that the SCCT model fails to present variation even when used across cultures. For example, Casas and Blanco-Blanco (2017) tested the SCCT model with Colombian Secondary school students within the Mathematics and Science fields. Almost 3000 students participated in the study during which they were evaluated for self-efficacy, outcome expectations, interests, aspirations and social support to have a career in Mathematics and Science. The following four hypotheses regarding the SCCT prepositions were developed and tested:

Hypothesis 1: self-efficacy and outcome expectations predict jointly interests in math/science;

Hypothesis 2: Math/science self-efficacy contributes to outcome expectations, and also affects interests indirectly through outcome expectations;

Hypothesis 3: Interests in math/science are predictive of occupational considerations in this field;

Hypothesis 4: Self-efficacy and outcome expectations affect occupational aspirations in the math/science field both indirectly (through interests) and directly (Casas and Blanco-Blanco, 2017, p.1177).

Results confirmed the first three hypotheses and revealed invariance across gender and ethnic group. Lent et al. (2010) emphasise the adequacy of the SCCT model to predict interest and choice goals. The study was an adaptation of a study which had been previously conducted within the Italian education context. 600 Portuguese Secondary school students participated in this inquiry which focused on two factors (1) the appropriateness of the SCCT model across the six Holland's RIASEC themes (Holland and Nichols, 1964); and (2) the specific hypothesis of the SCCT model relating self-efficacy and outcome expectations to the development of interests. Results indicated invariance to the hypothesis formulated within the SCCT model. Factors of support and barriers did not directly relate to career choice consideration; however, they were indirectly related through self-efficacy and outcome expectations.

Both studies confirmed the main hypothesis in the SCCT model which indicates that minor variances can occur across cultures.

Other studies have tested the SCCT propositions without having confirmed them. For example, Nugent et al. (2015) presented a study in which an adaptation of the SCCT model for the development of career interest was fundamental to understand that phenomenon. While the traditional SCCT model focuses on interest stemming from outcome expectations and self-efficacy, Nugent et al. (2015) showed that factors such as family, peers and educators influenced participants' interest in STEM. Such interest also seemed to predict the development of outcome expectations and self-efficacy towards STEM, which is exactly the inverted process illustrated in Figure 2.2. In other words, SCCT could be considered a model of development of career interest which is suitable to explain individual cases within contexts such as those in Brazil and capable to consider the influence of learning experiences such as ER approaches (Lent & Worthington, 1999; Lent et al., 1994). For those reasons, the SCCT model was selected to be the theoretical framework used in this inquiry.

2.9. Summary

This chapter has presented a review of the literature about robotics in education and its impact on career interest. The selection of SCCT as a theoretical framework has also been addressed and justified within a detailed discussion and critical review of traditional vocational psychology theories. The key reasons for the selection of SCCT were twofold: (1) the possibility to include contextual backgrounds which might influence one's career decisions; and (2) the importance of the learning experiences (such as ER approaches) as fundamental in the process of development of vocational behaviour.

As previously mentioned, Brazil is one of the many countries where there has been a prolonged shortage of professionals within the technology field (especially in areas related to Engineering and Computer Science). Ultimately, one of the goals of this study is to investigate to what extent the participation in educational settings providing mixed-ER approach curricula (competitions, projects, classes) develop an interest towards technology careers in young learners attending Primary and Secondary schools.

According to Lent et al. (1994, 2002), SCCT provides a comprehensive explanation and a model for the process regarding the development of interest towards a certain career. SCCT is also a theory that explains the development of academic interest and performance attainment stemming from learning experiences. Development of self-efficacy and outcome expectations stemming from those experiences could lead to one's interest in, for example, a subject related to robotics, programming or science after having participated in an ER club or afterschool project. This interest, in turn, might lead to the development of goals, such as completing a technology-related college degree or working with robotics in a near future.

This chapter also reviewed studies which evidenced the positive impact of ER on interest towards technology stemming from interventions based on ER competitions (Griffith Jr, 2005; Holland, 2004; Karp & Maloney, 2013), and ER classes (Jewell, 2011; Nugent et al., 2010). However, there had been limited or non-existent evidence of ER projects as interventions capable of influencing the development of interest towards technology.

Other studies which have been reviewed indicated that ER is an intervention that can impact on the development of technology skills (Nugent et al., 2010, 2014). Alongside the development of interest towards technology, the development of skills (and proficiency regarding such skills) are important steps within the process of development of interest in a technology career. Hence, individuals who considered themselves to be self-efficient or to have positive outcome expectations' beliefs towards programming could develop an interest towards a specific language (e.g. C++). In time, those individuals, through testing their abilities, could establish goals towards a certain trait (e.g. attending a programming course or deciding to go to college and take a degree in Computer Science).

In this chapter, it has been argued that there has been limited evidence of the impact of ER on career interest towards STEM. Evidence is even more limited if the impact of ER is restricted to career interest towards technology. Craig (2014) emphasised that the influence of ER competitions (FRC) on the development of interest and career choice goals towards STEM careers. Additionally, the study conducted by Duran et al. (2014) unveils a connection between the impact of ER classes and projects on career interest towards STEM.

Although limited, studies have supported the claims regarding the impact of ER (Griffith Jr, 2005; Holland, 2004; Jewell, 2011; Karp & Maloney, 2013; Nugent et al., 2010) and the impact of other types of interventions which are unrelated to ER (Awan et al., 2011; Gottfried et al., 2017; Krapp & Prenzel, 2011; Potvin & Hasni, 2014a, b) on interest towards technology. According to Lent et al. (2002), the development of interest towards a topic such as technology could lead to the development of career choice. The difference between ER approaches (competitions, projects and classes) and other types of interventions (inquiry, science museums, science fairs, summer camps, field trips, etc) seems to lie in the way they have been applied in education. Mubin et al. (2013) argued that ER could be applied according to a specific domain, a given place, a certain robotics kit, the way the robot is used or a chosen educational theory. Furthermore, ER differs from other educational tools for its hands-on aspect and for providing a problem-based approach (Bers et al., 2013; Conference & Alimisis, 2012; Eguchi, 2015; Nugent et al., 2014).

What follows is a description of how this research fits into the wider context of the ER field, highlighting the aspects that are addressed in it and where to find them in this doctoral thesis. This chapter has addressed the fact that most of the studies related to ER and career interest towards STEM are characterised as cross-sectional. This study was developed to be a longitudinal study (see next chapter), addressing the methodological gap identified through the reviewed literature, which allowed in-depth data gathering about this phenomenon in Primary and Secondary school students. This investigation also addressed a gap in the data about Brazilian population taking Basic Education curricula, which has been limited researched. Finally, reviewed literature has indicated the presence of limited data about two topics related to the impact of ER: 1) the development of career interest in technology (the 'T' in STEM) as a result of participating in ER approaches; and 2) the development of technology skills as a result of participating in ER approaches. By focusing on these two topics, this study contributed to the ER field adding data about these phenomena, which have developments for the process of implementation of full-time schooling in Brazil and the implementation of ER as digital learning curricula in Primary and Secondary schools worldwide.

The next chapter is an overview of the Brazilian education context. Understanding how the Brazilian education systems are organised and the impact that the laws, as guidelines, have on the education in Brazil is important for the clarification of the way

this study was proposed. The role that robotics has been playing in education is addressed – especially regarding the implementation of full-time schooling by the Federal Government since the beginning of the 21st century as part of the National Education Plan. Details about the educational setting which have been studied as cases for this investigation are also discussed in the next chapter.

CHAPTER 3 RESEARCH CONTEXT

3.1. Introduction

This chapter, comprising two main parts, presents an overview of the Brazilian education system in order to address how the development of technology skills and knowledge have been nurtured and implemented within the Basic Education curricula. The first part reviews the main changes in Education since the beginning of the democratic period in Brazil. In so doing, official sets of guidelines for curriculum development and implementation alongside facts and figures regarding funding are presented and discussed. The second part presents Educational Robotics as an afterschool activity as a regional and national plan and, more specifically, within the education system where this study was undertaken.

3.2. The Brazilian education system: levels of education and funding

Fausto (2012), in his book about the Brazilian history, suggests that the country lived through an intense period of social, political and economic adjustments after the end of the dictatorship in 1985. Historians, since then, have agreed on the “democratic era” terminology to describe Brazilian history since 1985 to date (e.g. Fico, 2015; Mota and Lopez, 2008; Napolitano, 2016). In order to re-establish a democracy, the Brazilian society needed a new constitution and new laws which could encompass the challenges of the new times. The drafting of a new constitution began in 1987, being finished in September, 1988 (Fausto, 2012). According to Júnior (2006), the Brazilian education system started to be redesigned two years after the promulgation of the new constitution, in the 1990s to accommodate the changes stemming from the new democratic period that had started in 1985. Those changes would redefine the Brazilian education system by establishing standards for all the aspects related to the structure and operation within public and private education in the country. In particular, the Brazil's Statute of the Child and the Adolescent (Brasil, 1990) established the concrete measures that government and society should take in order to protect children and young people's rights (Aranha, 2006). Importantly, it established the right to free education for all Brazilian citizens.

The law which establishes the main principles and guidelines for the development of the education system in Brazil in the new democratic era is the Law Nº 9.394 1996. This law states that the Brazilian education system comprises all the public and private education systems within the national territory. Those systems are organised by the 'Union, the States, the Federal District and the City Councils' in a 'collaboration system' (Law Nº 9.394 1996, S. IV 8A). The term "Education" involves the *Basic Education* and the *Higher Education* levels. *Basic Education* is related to *Pre-Primary School* (for children between 0 and 5/6 years of age), *Primary School* (for pupils between 6/7 and 14/15 years of age) and *Secondary School* (for pupils between 15/16 and 17/18 years of age). Students can apply for Higher Education after having concluded their Secondary School studies if they meet the selection criteria of a specific university. To date, students can usually apply for places in undergraduate courses within Brazilian universities through the following two methods:

- (1) National Secondary Education Examination (ENEM – Exame Nacional de Ensino Médio) which is the examination that is managed by the Ministry of Education and ranks secondary students from public and private schools who want to apply for a spot within a Brazilian public university; and
- (2) Vestibular examinations which are similar to ENEM but each public and private university manages its own vestibular examination.

Based on the student's scores, they can apply for a place in a specific undergraduate course at a university through programmes such as the ProUni or the Sisu. ProUni (University for All Programme, or, in Portuguese, Programa Universidade para Todos) is a programme which concedes partial or full undergraduate scholarships for secondary students according to their scores in ENEM. Sisu (Unified Selection System, or, in Portuguese, Sistema de Seleção Unificada) is a system that is used by the public federally- and state-funded universities to place secondary students in undergraduate courses (Júnior, 2006).

The Law number 9.394 1996 established the general parameters for the operationalisation of the education systems which are federally-, state- and municipally-managed. According to Filho (2001), the Law number 9.394 1996 was very important for several reasons, including the fact that it was the first law establishing the responsibility of all federate members in developing an educational plan after the dictatorship in Brazil. The Brazilian Federative Republic Constitution

1988, C.III SI 205A establishes that 'education, a right of all and a State and families' duty, will be promoted and encouraged with the collaboration of the entire society'. One of the intrinsic goals of this law certainly was to confront the enormous problem of illiteracy, which, in 1996, had reached 14.7% (MEC, 2003). Until 2012, however, the illiteracy rate would reach more than 13.9 million Brazilians, or 8.7% of the entire population (Souza, 2013). According to a recent study about the development of a functional index applied to the Brazilian context (Lima et al., 2016), 27% of Brazilians between 15 and 64 years of age can be considered functionally illiterates.

2002 people who represented all Brazilian regions from rural and urban areas participated in a study which aimed to develop a functional literacy index (or INAF). An instrument, which was based on the International Adult Literacy Survey developed by the Organisation for Economic Co-operation and Development (OECD), was used as a model for that investigation. Results indicated that 27% of the participants between 15 and 64 years of age were considered as functional illiterates. From 2000 to 2010, Brazil endured a low decrease in its percentage of illiterates: from 12.4% to 10% (Pierro, 2010). Amongst some of the reasons for that frustratingly low decrease and delay in solving those issues, unsuccessful programmes (e.g. literacy programmes for adults), the low quality of the teacher education courses and the lack of programmes focusing on that specific population must be mentioned (see Brasil, 2013; Pierro, 2010; Lima et al., 2016).

In order to address these issues, the Law N° 12.796 2013 established that a school year should incorporate at least 800 hours of educational work that are distributed in a minimum of 200 academic days. The Federal investment in all levels of education, in 2000, reached 3.5% of the Gross Domestic Product (GDP) whereas, in 2005, there was an increase for 4.4% of the GDP and, in 2010, for 5.6% of the Brazilian's GDP (MEC, 2014a).

Nevertheless, due to the continental size of the country (with more than two hundred million residents), challenges in school education are abundant nationwide (Fausto, 2012), despite programs such as ProUni and SisU. Particularly, increasing the access to higher education (Aranha, 2006). Those problems seem to be the result of decades, if not centuries of economic inequality that created a gap between rich and poor Brazilian citizens (Fico, 2015). It does not seem a surprise that this economic equality issue also has its ramifications in education, and developments of it are seen over all the education levels.

For instance, studies have been showing the difficulties students from public schools in Brazil have when they decide to pursue their studies in the higher level are bigger than the ones who come from private schools. Between 1980 and 2015, the number of students in the higher education levels increased almost 500%, from 1,4 to 8 million students (Schwartzman, 2016). Nonetheless, a study from Schwartzman (2016, p. 79) indicated that students from public schools have been achieving lower scores in the national admission tests to the universities (ENEM) since 2009. According to the last national census, 75% of the students who were matriculated in the best national universities (the public ones) come from private schools, while only 25% come from public schools (INEP, 2017). Góes and Duque (2016) indicated that the chances of a student to get a place in a public university is directly proportional to their family income. One of the consequences of this problem is that the students from low family income backgrounds usually have to go to paid private universities if they want to pursue their higher education degrees, increasing the economic inequality gap (Góes and Duque, 2016).

3.2.1. Guidelines for Basic Education in the Democratic Era and its significant goals: full-time schooling

Several guidelines addressed specific aspects of education after the development of the Law Nº 9.394. The *PCN (Parâmetros Curriculares Nacionais*, or National Curriculum Guidelines) established the minimum number of topics and the skills and competences related to each mandatory subject, such as Maths and Portuguese, for all the stages that comprise the Basic Education of public schools (see MEC, 2000; MEC/SEF, 1998; Ricardo, 2011; Ricardo and Zylbersztajn, 2008). It is important to highlight the existence of a determination which states that private schools are not obliged to comply with the PCN; however, the minimum number of mandatory subjects on their curriculum, such as Mathematics, Portuguese and Science, must be observed.

The PCNs was also the first Brazilian education guidelines which addressed the role of technology in the context of Basic Education (MEC, 2000a). Nevertheless, at the time, technology would refer mainly to information and communication technologies (e.g. desktop computers and software). The main objective was to instigate the use of ICT (Information and Communication Technologies) within Basic Education, the understanding and the basic uses of hardware and software and its connection with

other subjects (MEC, 2000). The guidelines regarding technology were developed in a time during which Brazilian public schools were equipped scarcely with Informatics resources. Thus, the inclusion of Informatics as a subject within the Basic Education curriculum had the goal to 'allow the access to informatics of everyone who intend to transform [informatics] in an element of the culture' (MEC, 2000, p.58). Until the 2000s, nonetheless, little was known about the impact of the implementation of ICT in educational settings within the Brazilian context due to factors such as lack of investment and difficulties in implementing technology education programmes nationwide (Junior et al., 2010). The PCNs helped to estipulate a set of competences and skills to be developed during the three-years period of Secondary School.

As an attempt to provide educational settings with proper funding to incorporate those guidelines regarding technology and informatics, several laws and amendments were approved. Amongst which, the following are more significant for this study

- (1) Law 9.424 1996 that created the Fund for Maintenance and Development of Basic Education and Teaching Valorisation (FUNDEF) which is a state-managed federal budget to fund Basic Education in Brazil (Júnior, 2006). In 2007, FUNDEF was expanded to provide funding for all the levels of the Basic Education, including Secondary School (CGU, 2012), having its name changed to Fund for Maintenance and Development of Basic Education and Educational Professionals Valorisation (FUNDEB). Theoretically, both funds had been created to guarantee that, in the case of lack of resources at the State or City Council levels, the budget for Basic Education would be supplemented by Federal resources. However, according to Filho (2001), those problems were not solved by the implementation of those funds mainly due to disorganization and corruption;
- (2) Laws N° 10.172 2001 and N° 13.005 2014 which created and revised, respectively, the National Plan for Education (PNE) (Federal, 2001; MEC, 2014a). The PNE proposed medium- and long-term goals to be achieved within the entire Brazilian Education System such as (a) to guarantee the right and the access of all to quality Basic Education; (b) to decrease inequalities and emphasize diversity; and (c) to increase the salary of schoolteachers and provide the practitioners with professional development.

Regarding technology within the curriculum and the development of human resources, the PNE proposed both an increase in the amount of funds to equip schools with the needed structure; and a set of actions to provide continuous teacher development and specific training (MEC, 2014a). The PNE also addressed the need to increase the number of hours on the school shifts, from four hours a day – the usual time per shift that Brazilian public schools offer to primary and secondary students – to eight hours a day (MEC, 2014). Until 2010, public schools, which represent more than 85% of the educational settings for Basic Education in Brazil, had to offer at least 4 hours a day as a school shift. Public Schools rarely offer more than 4 hours due to the number of students who are matriculated in Basic Education. Those students can attend a 4-hours shift in the morning *or* in the afternoon, which limits their exposure to learning opportunities within an educational setting (Júnior, 2006). Only public schools where afterschool activities are available are expected to offer their students the opportunity to attend classes both in the morning and in the afternoon.

Four-hours shifts in public schools seem to affect the education professionals as well. Frequently, school teachers and staff have to work in more than one school due to the lack of professionals in one educational setting during a specific school shift (MEC, 2014). For example, public schoolteachers under a 40-hours contract can have those 40 hours distributed amongst several grades and different schools within the same City Council or State. In other words, a schoolteacher who teaches the morning shift (usually from 8.00 to 12.00) might have to teach the afternoon shift (usually from 13.30 to 17.30) at another school. Through the More Education Programme (PME), which was developed in 2007, and other initiatives, state- and municipally-managed education systems could provide full-time schooling (eight instead of four hours a day) in the context of Basic Education (Leclerc and Moll, 2012; Penna, 2014).

The PME provided over 49,000 Brazilian public schools with federal funding to develop workshops in the opposite shift of that during which the students attended regularly. That way, students who attend school in the morning can participate in the workshops in the afternoon and vice-versa. The public schools have to apply for that funding by submitting a project. After having the school project accepted, each school may choose from ten learning macro-fields (such as supporting learning, environmental learning, educational technologies) to provide six workshops during

the week (Moll, 2009). One of the activities available through the PME is educational robotics (MEC, 2013). Although we do not have official figures to indicate the number of public schools which develop robotics activities since the implementation of the PME started, it seems that, at least, the programme enabled public schools throughout Brazil to access this opportunity (MEC, 2013; Ribeiro, 2012; SEB/MEC, 2011).

The implementation of full-time schooling is not finished and, according to the PNE of 2014, the goal is to implement it in 50% of the Basic Education Schools until 2020 (MEC, 2014). Critics of the programme indicated that several issues, such as lack of investments and structure to accommodate students full-time, curriculum integration and implementation of democratic processes, would have to be overcome in order to make full-time schooling available for all Basic Education students (Cavaliere, 2002; Leclerc and Moll, 2012; Penna, 2014; Titton, 2012).

At the Secondary School level, the implementation of full-time schooling seems to be particularly challenging because this level lacks an education reform, which has been discussed, but not yet acted upon, since 2000 (Federal, 2001; Krawczyk, 2013; Silva, 2013). Amongst some of the reasons why the Secondary School Level needs a reform, the lack of a common curriculum and the preparation for the world of work must be emphasised (Silva, 2013). The debate around possible changes to the Secondary School education refers to the need of full-time schooling; the disconnection between the school and the real-world issues (for example, the curriculum and the work market); the length of some tables of content regarding the mandatory subjects; poor laboratory infrastructure; and the lack of hands-on activities (Krawczyk, 2013; Silva, 2013).

Regarding the implementation of full-time schooling within the Secondary School level 'the Ministry of Education guidelines for the full-time schooling point out that they will be a result of what will be created and developed in each school, each educational system, with the participation of educators, students and the community' (MEC, 2014, p.11). Those activities could be developed inside or outside the school premises, under pedagogical orientation, through the use of public equipment and/or the establishment of partnerships with local institutions or other private entities (MEC, 2014). At the Secondary School level, the programme which has been helping the implementation of full-time schooling is the Ordinance N° 971 2009, or Innovative

Secondary School Programme (Pro-EMI). This programme is regulated by the National Fund for Educational Development (FNDE) through the Resolution N° 4 2016 and establishes that learning activities, in the context of curriculum integration fields, must be part of each school plan. Amongst those learning activities, the following are emphasised for the purposes of this study:

- (a) pedagogical monitoring;
- (b) research and scientific initiation;
- (c) world of work;
- (d) foreign/additional languages;
- (e) body culture;
- (f) production and fruition of arts;
- (g) communication, use of media and digital cultures; and (h) youth leadership.

For instance, states such as Rio Grande do Sul (where this study took place) and Pernambuco, respectively, started or have been implementing full-time schooling in the Secondary School level according to those Federal guidelines since 2009, at least. In Rio Grande do Sul, between 2010 and 2014, the state government implemented full-time schooling developing primarily learning activities related to the b, g and h curriculum integration field topics (SEDUC/RS, 2014). Pernambuco, in turn, has been implementing gradually full-time schooling for secondary students and their model of implementation aims mainly to increase the time during which the students are in school (approximately between 35 and 45 hours per week, depending on the infrastructure that the school can offer to each modality of full-time schooling). In terms of the topics of the curriculum integration field, those schools have been adopting topics relate to the a, b, c, and e (MEC, 2015).

If the last seven years have been highlighted by Secondary School reform attempts from municipal and federal entities in Brazil, it is not possible to say that those attempts were enough to address issues such as functional illiteracy as well as bridge the distance between schools and the world of work (Krawczyk, 2013; Silva, 2013). A study about the implementation of the Ordinance N° 971 2009 in secondary schools in the capital city of Paraná by Silva (2013) investigated whether the application had been similar, and the guidelines had been followed strictly or whether implementation had varied from school to school. The results indicated that only some (less than 1/3 of the schools) developed projects for the secondary school reform that had followed

strictly the directives (Silva, 2013, p.458). When questioned whether the schools should adopt the official directives which are included in the Ordinance as they were written, the response would be that the process of implementation needs to be contextualised so that an adapted version of the official document can be enacted. For instance, when it was expected that an approach with the world of work should happen through learning activities, most of the schools developed projects rather than building a closer relationship with private companies and/or public services.

Since the beginning of the democratic era, the country has seen changes regarding the way post-school transition has been conducted and how does it affect their future participation in the labour market (e.g. Aranha, 2006; Schwartzman, 2016, 2018). In his study about the post-school transition in Brazil, Schwartzman (2018) analyses the trends in formation education and choices of majors taken by youth on the last two decades. The study indicated that students prefer higher paying degrees (usually bachelor's degrees, responsible for more than 50% of matriculations) over licentiate degrees - responsible for around 30% of matriculations (Schwartzman, 2018). The study also indicated that the national education system seems to relegate the preparation for the labour market to a few schools nationwide, which provide professional courses in the secondary school level to nearly 10% of secondary school students (Schwartzman, 2016, p.44).

As previously reviewed in this chapter, the distance between the preparation for the labour market and the goals of Basic Education in Brazil have been promoting the debate and governmental actions towards a reform in secondary school (e.g. Schwartzman, 2016; Silva, 2013). Currently, the education system in Brazil allows that only a low percentage (20%) of secondary school students will have access to higher education, and only a half of those will be able to finish it (Schwartzman, 2018, pp.29–30). Since studies have indicated that there is still a connection between high paying salaries and one's level of education (e.g. Oliveira and Puc-minas, 2016; Schwartzman, 2016, 2018), participation in the labour market has been a challenge for Brazilian youth. Contributing to that reality are factors such as lack of professional experience and education (Fausto, 2012; Resende et al., 2016). With the implementation of secondary school wide reform, solutions for the post-school transition would include a deep the availability of more professional courses and a curricular that could bridge the path from school to the world of work (Silva, 2013). In this sense, it seems that afterschool activities such as ER have been providing

learning opportunities that have been bridging the gap between labour market during the post-school transition period.

This section has presented and discussed the challenges regarding the implementation of full-time schooling in primary and secondary schools within the Brazilian public education system. PME and Pro-EMI have been highlighted as the most significant initiatives for the development of Primary School and Secondary School, respectively. Students who attend the nine years that comprise the Primary School level in Brazil can enrol in technology-related activities, such as robotics, as long as the school adds those activities as part of their six-activities plan to be developed. However, during the three-years period of Secondary School, educational settings usually cannot access the same funding that is provided by PME. Because of several reasons, amongst which the lack of a comprehensive educational reform that involve the secondary school level, opportunities for professional training and for the development of activities within the technology field have been extremely rare (Krawczyk, 2013). Finally, trends on post-school qualification and youth labour market are discussed. It is highlighted that only a small percentage (20%) of the students have access to higher education, and that only around 50% is able to finish their degrees (Schwartzman, 2018). Therefore, further education opportunities such as technological courses and online distance courses have been becoming more important, especially for the youth (Schwartzman, 2016).

The following section addresses the additional opportunities for technology-related professional training that have been helping mainly, but not exclusively, the Secondary School level in Brazil. Public and private educational settings have been providing students with learning opportunities during the opposite school shift as an effort to implement full-time schooling.

3.2.2. Full-time schooling and afterschool activities that provide technology learning

As previously discussed, since 2009, the Brazilian government have attempted to provide primary and secondary students with full-time schooling through education programmes. Issues such as functional illiteracy, lack of pedagogical support and insufficient time in school have been presented as the main concern by those programmes. In addition, programmes such as Pro-EMI were created to bridge the

distance between secondary school and the so-called “world of work”. However, the task of creating practical solutions for those problems were managed mainly by the school boards. Because Brazilian public schools’ boards usually have to deal with several issues related to budget cuts and lack of infrastructure, at times, the government policy and/or guidelines regarding those programmes cannot be adopted and/or followed fully (Silva, 2013). The outcomes of implementing partially the programmes have not been ideal; however, as a result, the need for an educational reform which focuses on the Secondary School level has been made clear and groups of decisionmakers have started to address such necessity (e.g. Krawczyk, 2013; Silva, 2013).

Amongst the Brazilian private institutions which aim to bridge the gap between primary and secondary school and the world of work by providing updated professional training, the National Service for Industrial Apprenticeship (SENAI – Serviço Nacional de Aprendizagem Industrial) must be highlighted. SENAI is a non-profitable private institution that offers and promotes seventeen courses that focus on professional training within over twenty-eight areas of Brazilian industry (e.g. mechatronics, electronics, mechanics and automation) to approximately two million students in Brazil (SENAI, 2012). Other similar institutions, which are part of the S System⁷, offer the same services for students who are interested in other economic areas such as transportation (SENAT), commerce (SENAC) and the rural sector (SENAR). Nevertheless, the number of vacancies which are usually offered by those institutions is substantially fewer than the number of students who are interested in being trained at one of the institutions within the S System.

The number of private courses in the area of technology, for example, increased 9.3% in 2013 (INEP, 2013). Informatics and Mechatronics were between the ten courses which are most sought by secondary students and adults who attend private

⁷ The *S System* is the set of educational systems that provide training courses which are related to the most significant economic sectors (SENAI for the industry sector, SENAT for the transportation sector, SENAC for the commerce sector, etc). The system is privately funded by industries of each sector; however, free professional training is also provided. Private companies which help to fund those educational system receive tax exemptions from Federal, State and Municipal governments. Although the main funds come from private companies, those educational settings provide services under contracts which originate a reasonable source of income (Manfredi, 2002). The *S System* has been providing professional training for over 75 years in Brazil and therefore is considered to be the most traditional option for professional training. However, there are some requirements regarding age, schooling level and previous knowledge which restrict universal access to such courses.

institutions (more than 92,000 and 26,000 matriculations, respectively). Informatics and Electronics which are offered at federal institutions received more than 29,000 and 6,000 matriculations, respectively, whereas public institutions received more than 92,000 matriculations for Informatics and 27,000 matriculations for Electro-electronics (INEP, 2013, p.28-29).

The Young Apprentice Programme (PJA – Programa Jovem Aprendiz) is another programme that aims to provide professional training through learning opportunities alongside especial employment contracts. Through PJA, students from 14 to 24 years of age can apply for training courses or job opportunities which are offered by companies and educational settings that participate in the programme (Brasil, 2011). PJA was designed to prioritise the inclusion of students according to their social status; that is, PJA aims to facilitate the placement of low-income students into the work market (Matsuzaki, 2011). Amongst the requirements to participate in PJA, students must be matriculated in a primary school, secondary school or a professional course. The available vacancies are regularly and widely adverted in the mainstream media and specific websites.

Besides the initiatives such as Pro-EMI, the S System and PJA, Brazilian primary and secondary students have, at least, two other options of afterschool learning activities which are related to technology: (1) enrolling in courses that are offered by private schools; and (2) joining free activities that are available within the Open School for Citizenship Programme (PEAC – Programa Escola Aberta para Cidadania). Although figures which could present accurately the real situation regarding the current availability of technology-related courses, a recent online search that was conducted⁸ privately revealed that seventeen technology-related courses could be found in the central area of Porto Alegre. However, fewer courses can be found in public schools which participate in PEAC within Rio Grande do Sul (RS) – the state where this study took place.

The official sources indicated that there have been more than 200 educational settings that provided learning activities which focus on culture; youth leadership; the

⁸ Research was conducted on 01/12/2016 via search tools such as Google, Google Scholar and Bing. The variables used were: "Informatics Course" OR "Technology Course" AND "Porto Alegre area" AND "Price". The last variable was used to select solely the private courses. ⁹ http://www.educacao.rs.gov.br/pse/html/escola_aberta.jsp?ACAO=acao1 Accessed on 01/12/2016.

democratisation of public spaces; and the development of citizenship⁹. Although rare, learning activities that involve computing training or robotics training are also available as afterschool activities through the programme⁹. Theoretically, those programmes have been the only opportunities for professional training and leisure in areas where most of the students come from low-income families (Da Costa et al., 2011). At least a few studies have indicated that non-traditional educational settings such as those within PEAC, promote continuing education for both students and teachers (e.g. Da Costa et al., 2011; Souza, 2008). Nevertheless, the lack of experts and investment can prevent the development or the continuity of activities that involve technology (da Costa et al., 2011, p.576-7).

This section discussed technology-related full-time schooling and afterschool learning activities that are provided by several Brazilian education programmes which were presented considering their range, requirements and main desired audience. Programmes such as Pro-EMI, which has similar goals as those of PME, have been increasing the number of school hours for secondary students who, in turn, have the opportunity to develop skills that might be helpful academically and/or in terms of employability. This section also presented some of the S System programmes which provide professional training and internship opportunities and PJA that goes beyond the S System programmes by offering an employment contract for students between 14 and 24 years of age. Those programmes offer training and employment opportunities in the fields that involve ICT/Technology sector. Finally, other technology-related afterschool learning and/or training opportunities that are available in Brazil, such as PEAC and private courses of Informatics/Educational Robotics, were addressed.

3.3. Educational Robotics as an afterschool activity: the implementation of full-time schooling in Brazil

Public schools have been responsible for 81.7% of the students who enrolled in the Basic School levels in Brazil (Primary and Secondary) whereas private schools are

⁹ For more information about educational robotics training activities that are developed through the programme, visit <https://www.alvorada.rs.gov.br/alvorada-oferece-cursos-paraalunos-da-eja/> or <http://nte-poa.weebly.com/> (accessed on 01/12/2016). For information about ICT training activities that are developed through the programme, visit <http://www.todospelaeducacao.org.br/reportagens-tpe/32893/de-portas-abertas/?pag=4> (accessed on 01/12/2016).

responsible for 18.3% (MEC, 2014). As it has been argued previously, the Brazilian educational context has been through intense changes since governmental actions, such as the funding programmes and guidelines for education, were developed with the intention to expand and improve the quality of Basic Education. One of the most significant challenges has been the implementation of full-time schooling within the Primary and Secondary School levels. Activities such as robotics have been made available to public school students through PME; PJA; SENAI; and private and public individual initiatives (e.g. the Porto Alegre City Council Robotics Programme for primary schools).

The number of Educational Robotics (ER) workshops and clubs have been increasing in Brazil for the last eight years and so has the number of clubs that compete in ER challenges (FIRST, 2014). Amongst several reasons for such increase, two must be highlighted: (1) the 2007 decree which allocated federal funding to expand the school hours (from four to seven hours a day) in public schools; and (2) the availability of ER clubs in private schools (Beauchamp and Silva, 2008). The development of PME enabled over 49,000 public schools in Brazil to receive federal government funding in order to develop afterschool activities in the shift during which the students would not be attending regular classes. As it was previously addressed, the legislators believe that there is a need to provide better conditions for learning and increasing the amount of time that students stay in school has been one of the initiatives through which issues such as illiteracy can be addressed.

Public school boards need to submit a plan for those extra school hours in order to receive federal funding through PME. After having the school project accepted, each school board must develop a full-time schooling curriculum by choosing from the ten learning macro-fields that are available (e.g. school tutoring, environmental learning, educational technologies). In 2014, each public school which were participating in PME could choose up to six activities, from which school tutoring had to be one of the six activities, to be implemented in the curriculum (Leclerc and Moll, 2012). Thus, each school would provide the students with 35 hours a week of learning activities rather than the 20 hours a week which comprised the regular curriculum. ER, for example, is one of the possible choices of learning activities that are available through PME.

Each school could choose the learning methodology and robotics kits to purchase. Those decisions, which were found to be made by the school board and the PME coordinators, are resulted from the recommendations that are presented in the *Educational Technologies Guide* that is suggested by the PME coordinators (Beauchamp & Silva, 2008). Brazilian public schools whose boarders decided to provide the students with ER activities without the support of PME do not have to comply with the same requirements or achieve the same objectives – such as a mandatory number of activities or minimum of 35 hours a week for the development of the activities – as the schools that participate in the program. Brazilian private schools usually outsource those services from companies which are specialised in offering ER curriculum and learning support or develop their own curriculum and/or methodologies¹⁰.

There are several reasons why public and private schools worldwide choose to develop ER clubs and workshops to participate in competitions with their teams. Developing students' interest and content knowledge in science, technology, engineering, and mathematics (STEM) is, for example, one of those reasons and, for the purposes of this study, the most important reason. In a country such as Brazil, where there is a significant lack of interest in STEM careers and where the number of students who are interested in attending STEM-related undergraduate courses decreases each year, initiatives such as ER clubs seem to be valuable (Resende et al., 2013). Moreover, companies which are specialised in offering ER services have claimed that the participation in ER competitions and their ER curricula can influence positively career interest of secondary and post-secondary students, especially, in STEM-related careers (Robinson and Stewardson, 2012).

¹⁰ PETE (<http://pete.com.br/pt/home/>, accessed on 25/12/2016) and ROBOMIND (<http://www.robomind.com.br/> accessed on 25/12/2016) are examples of companies which provide outsourced educational robotics activities that can be developed in the opposite shift. For example, ROBOMIND was found to be more active within the three Southern States of Brazil whereas PETE was found to be active nationwide. Both companies offer methodological advice and the robots as products which can be purchased. One of those companies has been recommended by the Education Ministry in the *Educational Technologies Guide*. Private Educational Systems such as the Group of Marist Schools (<https://colegiosmaristas.com.br/> accessed on 25/12/2016) and the Sinodal Group (<http://redesinodal.com.br/portalrede/> accessed on 25/12/2016) were able to develop their own educational robotics methodologies and curriculum, as well as their own competitions and a specialised workforce to provide students with robotics activities during the opposite shift. They were also able to integrate educational robotics as a learning tool in their Basic Education curricula.

3.4. Summary

This chapter has presented an overview of the Brazilian educational system in order to clarify the importance of having ER activities within the government agenda regarding the implementation of full-time schooling for the public education system. According to PNE, the main goal that the federal government aim to achieve is the increase of school hours (from four to eight hours a day) for at least 50% of students who are matriculated in Basic Education (Primary and Secondary School Levels).

It has been explained that the Brazilian education system comprises private and public education institutions which provide the following levels of education: (1) Preschool; (2) Basic Education, which is divided into primary and secondary school levels; and (3) Higher Education. Since this study investigated the impact of ER on primary and secondary students, the focus was on how the Basic Education is organised and managed in Brazil. Furthermore, the structure and guidelines for the development of curricula within public schools were presented, since they cover more than 80% of the education system in Brazil.

It has been established that the organisation of the Brazilian education system has been outlined by the Law number 9.394 1996 and that the PCNs offer curriculum guidelines for the Basic Education levels. Those documents were developed with the objective to address several issues regarding education in Brazil, amongst which, the following must be highlighted: (1) the high illiteracy rates throughout the country; and (2) the universal access to Basic Education. Governmental plans, such as PNE, that established many objectives to be achieved (e.g. full-time schooling) in order to improve the quality of education have been described in this chapter.

ER-related initiatives have been part of afterschool activities that are developed in the opposite school shift. Three educational settings (one within EMEF José Mariano Beck and two within CESMAR), where this study was undertaken, have been presented in terms of the social impact that the implementation of full-time schooling through ER groups/courses has had in the community. The relationship between the context of changes in education and the characteristics of the curriculum has been acknowledged. The implementation of the main ER approaches in each educational setting has also been highlighted in terms of their relationship with the calendar of ER events. The following chapter focuses on the methodology for this qualitative study.

CHAPTER 4 METHODOLOGY

4.1. Introduction

The purpose of this inquiry was to investigate the extent of the impact of ER approaches (such as competitions, projects and classes) on the development of career interest in Brazilian primary and secondary school students. This chapter overviews the research design implemented in this study to achieve such goal. The Social Cognitive Career Theory (SCCT) (Lent et al., 1994) was the theoretical framework informing this study in order to understand whether students were able to develop interests and career choices towards technology.

In so doing, this chapter was divided into eight main sections. Section 4.2 addresses the key characteristics of qualitative research and the reasoning for the selection of such approach. Section 4.3 focuses on the research design and the justification for the development of case study as a suitable approach for research in education (Hamilton and Corbett-Whittier, 2013). Section 4.4 presents the sampling strategy and the key criteria applied to this research project. Section 4.5 outlines the strategies used to enhance research quality, including the researcher's role and reactivity. Section 4.6 discusses how trustworthiness was assured throughout this study. Section 4.7 presents the methods for data collection which were used in this study: (1) interviews; (2) online journals; (3) participant observation; (4) document interrogation; and (5) researcher's fieldnotes. Section 4.8 describes the data analysis procedures used in this study whereas Section 4.9 concludes this chapter by specifying the ethical issues which had to be considered throughout the development of this study.

4.2. Qualitative Approach

Regarding the development of research projects in Social Sciences, Thomas (2013) suggests that a research design should address the type of research questions of one's investigation. Silverman (2013) and Merriam and Tisdell (2015) propose that such an approach towards research design should focus on the issue that one is trying to address rather than favouring a methodology/research design approach over the topics to be investigated. Creswell and Maietta (2002) and Silverman (2013) agree that the qualitative research have been frequently associated with (a) rich and

detailed outcomes; and/or (b) the investigation of a particular phenomenon. Given (2008) suggests that quantitative research seems to be related to empirical inquiry approaches which rely on data collection, analysis and display in numerical form.

A qualitative approach was chosen to develop this inquiry because of: (1) the need for in-depth research about the impact of ER on attitudes, skills and perceptions towards career interest to respond to the questions informing this investigation; and (2) the theoretical framework underpinning this study (based on SCCT). Furthermore, the reviewed literature (see Chapter 2) indicated that in-depth studies could shed a light on the understanding of the extent to which Primary and Secondary school students can develop both interest towards technology careers and technology skills. Studies about this topic, informed by theoretical frameworks such as the SCCT, could help researchers to understand *how* and *which factors* can be determinant on the process of development of vocational behaviours in young learners from Primary and Secondary school.

As previously stated, (see Chapter 2), this study can also be partially considered a longitudinal one. For case study 1 and 2 (CESMAR), the change in students' interest towards technology careers was followed throughout a period of approximately six months (from October/2015 until April/2016). For case study 3, the change in students' interest towards technology careers was followed throughout a period of approximately one year and a half (from November/2014 until April/2016).

The main research question guiding this inquiry is: *to what extent does participation in ER educational settings influences Primary and Secondary School participants' interest in technology careers?* According to Lent et al., (1994), career interest is a complex behaviour which can result from the development of self-efficacy and/or outcome expectations. If the perceptions about those factors are positive, one could develop interests and goals towards a topic of interest (e.g. technology careers). Participations in learning experiences during which self-efficacy is positively reinforced could nurture the development of interests and goals towards a topic and, often, career interest (Lent et al., 2002). Because of the *time* factor (diachronic case study approach) and the need to understand the connection between ER approaches and development of career interest (in-depth study), a qualitative research was developed in order to conduct this inquiry.

4.3. Research Design: case study approach

According to Lent et al. (2002) and Porfeli et al. (2011), career interest is a process that occurs, almost continuously, over time in one's life. Thus, qualitative approaches have been found to provide more effective tools to cope with such types of research than quantitative approaches (e.g. Silverman, 2013; Strauss and Corbin, 1997). There are several methodologies or approaches which can be applied to the development of a qualitative research. This section outlines and discusses the reasons why a case study was considered the most suitable approach around which this study was developed.

Yin (2009) emphasises three elements to be considered when a case study is chosen as a research method: (1) the type of research method one proposes; (2) the degree of control one requires in order to conduct the study; and (3) the focus (or lack of focus) on contemporary events. In this sense, this research project met all the requirements to be developed as a case study, since (a) it aims to investigate the process of interest development (e.g. how the interest towards technology careers develops over time? Or why is a specific ER approach more or less likely to nurture or hinder career interest?); (b) it does not require the researcher's control of behavioural events; and (c) it focuses on contemporary events. Thomas (2013) proposes that each stage of a certain study should inform the others especially because when the findings start emerging from data, 'you may wish to ask further, subsidiary questions, or you may wish to come back to your literature review to see if light can be cast upon an unexpected aspect of your findings' (p.127). In other words, the steps of the research design process communicate with each other within a loop.

Considering that this study aimed to explain the development of vocational behaviour towards technology stemming from ER approaches in Brazilian primary and secondary school students, the SCCT informed this investigation which was designed to include two educational settings where ER had been implemented in the curriculum. Three ER groups (or classes) were the contexts where this study was undertaken: two within Primary Schools and one within a Secondary School. The reviewed literature informed the research questions of this study (the extent to which career interest was developed through time), which, in turn, informed the research design (longitudinal multiple case study). By treating the subjects of the study as

cases, it was also possible to identify them as units of analysis (a) in relation to the theoretical framework; (b) within contexts (comparison between different participants in the same case study); and (c) across contexts (between the Primary schools, and between the Primary school and the Secondary school participants).

Merriam and Tisdell (2015) describe a case study as 'an in-depth description and analysis of a bounded system' (p.40). For Yin (2009), it is 'an empirical inquiry that investigates a contemporary phenomenon within its real-life context' (p.19). Pollard (1987), Stake (1995) and Yin (2009) propose that case studies could be used as a method, methodology or research design whereas Hamilton and Corbett-Whittier (2014) argue that a case study can provide 'guiding principles for the research design, process, quality and communication' (p.10). Despite presenting an account of the findings, case studies are not prescriptive in structure, content, or data collection tools.

Hamilton and Corbett-Whittier (2014) also claimed that case study in Social Sciences has evolved as an approach to research and has become capable of capturing rich data and able to establish an in-depth picture of a bounded unit or aspects of that unit. In this sense, a case study can be perceived as a method, a methodology and/or a research design. In this investigation, two bounded units (development of career interest and technology skills) were framed through a specific research design (a longitudinal case study informing process, quality and communication). The further results of this investigation and the research design here discussed do not indicate that this research design is prescriptive in nature; however, it could offer guiding principles of how the study was conducted from which future researches could benefit.

The nature of this investigation, the development of career interest, also contributed to the selection of the case study as a research approach. The reviewed literature revealed the existence of a gap in the ER field: the lack of follow-up studies on the development of career interest, which could be addressed by an in-depth approach to the subjects of research. Such approach often demands a variety of data gathering methods and, due to the complexity of the research questions, this study needed to be developed based on an in-depth research design rather than a single method, such as a survey (Stake, 1995). Hamilton and Corbett-Whittier (2014) see this as a positive aspect of the case study in educational research, since

The strength of such an approach by individuals or groups within and across institutions lies in the building of data which carries weight because it brings with it the richness of an in-depth case study with a diversity of social contexts and diversity of pupil, parent and teacher groups. The combination of depth and breadth helps to substantiate claims and conclusions (p. 19).

This section has explained the reasons why a case study, instead of alternative methods (e.g. surveys, experiments, action research) was chosen as a research approach for the development of this investigation. The next section discusses the sampling strategies which were applied to conduct such project.

4.4. Sampling Strategy and Justification

A qualitative study can be conducted around several sampling strategies – such as, homogeneous sampling (Miles and Huberman, 1994) and purposive sampling (Silverman, 2013) – as well as sampling criteria – such as the relation with the theoretical framework (Punch and Oancea, 2014) or the combination of research questions and the feasibility of the project in terms of data analysis, size of the cases and time. According to Punch and Oancea (2014), qualitative sampling in case study research involves ‘identifying the cases and setting the boundaries, where we indicate the aspects to be studied, and constructing a sampling frame’, alongside the selection of setting(s) as a next step (p.211).

All three case studies developed within this research presented similar demographics and social characteristics, which is the focus of an ‘homogeneous sampling’ strategy (Miles and Huberman, 1994, p.32). More than 80% of Brazilian students enrolled in the Basic Education attend Public Schools funded by the Federal Government, States Education Secretaries or City Councils, generally, located in deprived urban neighbourhoods or locations presenting a low index of human development (see Brasil, 2001; CGU, 2012).

Another sampling strategy used for this research study was purposive sampling. Jupp (2006) suggests that case study designs ‘often requires a purposive sample’ (p. 245). Silverman (2013) proposes that purposive sampling ‘allows us to choose a case because it illustrates some feature or process in which we are interested’ (p. 129). Amongst the reasons for selecting such a strategy, the selection of an educational setting because of its features or accessibility must be highlighted. The main

advantage of purposive sampling is related to the opportunity to choose between participants/cases that can provide relevant answers to the research questions (Jupp, 2006; Silverman, 2013). Within this study, the selection of educational settings considered the chance to compare the development of career interest towards technology between two different learning stages: Primary school level and Secondary school level. Such contexts were suitable, since the implementation of fulltime education curricula in Brazil has been done exclusively within the Basic Education levels (comprising Nursery, Primary and Secondary Schools).

Nevertheless, to diminish the researcher's bias on the choice of participants, a strategy for the selection was created. Only the oldest students participating in the ER groups at the investigated educational settings had their data analysed in this study.

The rationale for that was the specific characteristics of the Brazilian educational context, in which at the end of Primary and Secondary School students can apply for internships within Technical or Technological Courses, respectively. Moreover, it is not uncommon for companies to sponsor scholarships through the Young Apprentice Program (see Chapter 3 for further details) and offer part-time jobs at their companies to those students who want to have some professional experience. Senior secondary school students can also try to get into college and pursue undergraduate studies. Thus, purposive sampling was applied to select those students as participants for this study. Jupp (2006) argues that 'the principal disadvantage of purposive sampling rests on the subjectivity of the researcher's decision making' (p.246). This issue brings the risk of the researcher to be informed by a pre-conceived hypothesis about sampling, which could result in a potential threat to the validity of study findings and conclusions. In this sense, the criteria for this purposive sampling (the participants' age and overall experience within the ER group) helped to cope with the subjectivity of the researcher's decision-making process.

A sampling strategy can also create generalisability; therefore, according to Hamilton and Corbett-Whittier (2014), case studies can produce resonance 'for those in similar contexts, with similar issues, providing insights to help them understand, more fully, the nature of their own problems' (p. 145). Furthermore, sampled participants who share several characteristics (e.g. demographics, location, gender) with those attending classes at other educational settings in Brazil might enhance the chances

of producing resonance or fuzzy transferability (see Section 4.5.2.1 for further details).

The selection criteria of the educational settings where this research was undertaken comprised the opportunity to develop an in-depth study about the impact of ER approaches on academic and career interest towards technology. At least one context within Primary school and one within Secondary school were desired to be part of the study. It was also important to choose educational settings where ER approaches had been implemented successfully in the curricula soon after the establishment of the *National Education Plan* and the *PEM* (Brasil, 2001, 2014; SEB/MEC, 2011). Only two Brazilian States, São Paulo and Rio Grande do Sul, presented educational settings which met those criteria. The City Councils within those states' capitals, São Paulo and Porto Alegre, were found to be suitable contexts for this investigation. Invitations were sent to schools' headmasters and ER teachers from those cities; however, only the headmasters from the educational settings in Porto Alegre accepted to participate in the study. Two Primary Schools funded by the Porto Alegre City Council and one Technology Centre providing free-of-charge ER courses to Primary and Secondary School students were selected as potential contexts for this research. A preliminary study was developed in 2014 involving two Primary schools, which helped in the process of refining the methods and research design (Paula et al., 2015). After this study, one of the Primary Schools and the Technology Centre continued to be part of the research as the educational settings where the investigation was developed.

There had been more than 100 students participating in the ER group at Beck School between 2014 and 2016. Most of them had been part of the *PEM* and attended the ER classes as part of the new full-time education curriculum that had been implemented in 2007. At the ER group, students were divided into groups of 20 participants who would attend two-hour sessions during the week under the supervision of an ER teacher. Another group with approximately 15 students had been chosen, either due to merit or experience, to participate and represent the school in ER projects, challenges and classes. Some of the students from this group played the role of mentors to the newer students. Such students were frequently those who had already finished Primary school and were Secondary school students in a different educational setting. They would return to the ER groups in which they had participated to help the teacher as volunteers/tutors. The other students in that

ER group were usually first- or second-year attendees of the Robotics class who were eager to participate in competitions and/or projects. The older students in that ER group were invited to participate in this study. Six students and three mentors agreed to participate in the study and returned the informed consent forms signed by their parents, since they were under 18 years old.

The age criteria, which had been established previously, contributed to the implementation of a sampling strategy because it helped to enhance the validity by diminishing researcher bias (Punch and Oancea, 2014). Moreover, it justified the use of the theoretical framework informing this study for two main reasons:

- (1) the sampled participants' age range was similar to those in previous studies on the development of career interest towards STEM in primary and secondary school students (Craig, 2014; Lent et al., 1994; Ohashi, 2009; Patton and McMahon, 2006);
- (2) the sampling strategy helped to indicate participants and educational settings that could potentially provide meaningful responses to the research questions.

CESMAR provided the members of the community with several professional and technological courses – including an Electro-electronics course with emphasis in Robotics for secondary school students and a Socio-educational course with emphasis in Robotics for primary school students. All six students attending the Electro-electronic course agreed to participate in this study. Approximately twenty students were attending the Socio-educational classes in 2015. Six students were nominated by the teachers to participate in the study because they had been attending the classes for, at least six months. Four of those six students met the age and experience criteria and were included as participants in the study after having returned the informed consent forms signed by their parents. The Electro-electronic course had started in 2014 and was attended by ten students – eight females and two males. In 2015, the six female students were still attending the course and agreed to participate in this study with parental consent. Table 4.1 presents information regarding the participants of all case studies.

Table 4.1: Case Studies Participants

Educational Settings	Students	Gender	Age	Level of Education
CESMAR Socio-educational Course	Albus	Male	14	8 th grade/Primary School
	Darwin	Male	15	9 th grade/Primary School
	Nathan	Male	16	8 th grade/Primary School
	Ulrich	Male	16	1 st year/Secondary School
CESMAR Electro-electronics Course	Michelle	Female	19	3 rd year/Secondary School
	Anne	Female	19	Post-Secondary School
	Ethelyna	Female	19	2 nd year/Secondary School
	Luisa	Female	19	3 rd year/Secondary School
	Andrea	Female	20	2 nd year/Secondary School
	Amelia	Female	21	Post-Secondary School
EMEF José Mariano Beck	Andrew	Male	14	9 th grade/Primary School
	Peter	Male	12	7 th grade/Primary School
	Severus	Male	11	6 th grade/Primary School
	Sheila	Female	11	6 th grade/Primary School
	Daniel	Male	13	7 th grade/Primary School
	Donna	Female	13	8 th grade/Primary School

This section has discussed the process of sampling. Informed by the research design and particularities of the research questions, homogeneous sampling and purposive sampling were the applied strategies in this study. The next section discusses the positionality and the role of the researcher as an interpreter of findings.

4.5. Strategies to Enhance Research Quality

This section outlines the strategies used in this study to enhance research quality. The first part focuses on the roles that the researcher and the participants have played to contribute to the development of the study. The second part examines the strategies that allowed this study to claim trustworthiness.

4.5.1. Reactivity

According to Gibb (2008), reactivity occurs ‘when the subject of the study is affected either by the instruments of the study or the individuals conducting the study in a way that changes whatever is being measured’ (p. 694). Additionally, it is presented as a reaction to the environment as well. For Thomas (2013), since qualitative research focuses on the interpretation of the information gathered by the researcher, it is

important to understand this researcher's active position when making sense of that data.

Lavrakas (2008) proposes that there are three strategies to address reactivity in a survey:

- (1) being aware of how an individual could react to different aspects of the experience of being researched;
- (2) reviewing similar studies and their faults in order to not repeat them in your research; and
- (3) using a well-trained and monitored interviewer in the research process to reduce the likelihood of reactivity effects as well as strength external validity

Aiming to implement strategies to comply with reactivity, a pilot study was conducted in between November/2014 until June 2015, which allowed some of the questions within the interviews to be redefined and increased the awareness of the participants' behaviour during research. However, only case study 3 participants took a part in this pilot study, since ethical clearance for case studies 1 and 2 were granted only in the second semester of 2015. Another pilot study was conducted before fieldwork (2015), also with case study 3 participants due to the same reason previously explained. During this second pilot study, it was possible to improve the researcher's attitudes and the data gathering instruments, for instance, positively adapting the interview questionnaire to the demographical characteristics of the participants. The pilot studies enabled a better understanding about the data gathering processes to be developed through testing procedures. Amongst the series of preparatory procedures, the introduction of the researcher before the fieldwork facilitated rapport building and minimised negative reactions to a new situation – such as having a researcher in the educational setting (Gibb, 2008).

4.5.2. Trustworthiness

Benaquisto and Given (2008) define trustworthiness as 'the ways in which qualitative researchers ensure that transferability, credibility, dependability, and confirmability are evident in their research' (p. 895). It is also a set of tools that can be used for qualitative researchers to 'illustrate the worth of their project outside the confines of

the often-ill-fitting quantitative parameters' (Ibid, p. 896). The following sections highlight the trustworthiness strategies used in this study.

4.5.2.1. Transferability

Transferability is, in qualitative research, the equivalent of generalisability in quantitative studies, since it involves 'the need to be aware of and to describe the scope of one's qualitative study so that its applicability to different contexts (...) can be readily discerned' (Benaquisto and Given, 2008, p.895). In this sense, the worthiness of a study can be determined by the applicability of the findings within the contexts. This study's findings can be potentially transferable to other similar educational settings – especially in Brazil – where ER approaches could be implemented within a full-time education curriculum and/or afterschool activities (Dick, 2014). They can also be transferable to other contexts in which the students share demographics, such as sociocultural and economic backgrounds and age, with those participating in this study. Transferability could be possible for non-Brazilian studies, since the suggestions within SCCT have been successfully tested internationally (Blanco, 2011; Lent et al., 2010). This study could have methodological value to researchers applying SCCT as the theoretical framework within in-depth studies about the development of career interest, especially those seeking to unveil more details about such process.

4.5.2.2. Credibility

Similar to what internal validity represents within quantitative studies, credibility, in qualitative research, involves the accurate and rich description of the investigated phenomenon. For Benaquisto and Given (2008), when developing a qualitative research, 'instead of ensuring that one has measured what one set out to measure, one is making sure that they have accurately represented the data' (p. 897). In this study, research study plans were undertaken to establish trustworthiness of the data using: (a) multiple sources for data gathering; (b) triangulation within and across data sources during the analysis process; and (c) triangulation of perspectives (Hamilton and Corbett-Whittier, 2014; Yin, 2009).

Triangulation was not used for the same purposes as it would have been used within a quantitative research (e.g. cross-checking data); rather, it was used to increase knowledge about a topic (e.g. interest towards technology) through the use of more than one method of data gathering (Hamilton and Corbett-Whittier, 2014; Thomas, 2013). The same action was taken regarding the triangulation of perspectives, when different viewpoints had been used to interpret the received information about a given issue. For example, in Case Study 2, the teachers stated that there had been only one student who seemed interested in a technology-related career. However, four Case Study 2 participants claimed to have developed interest in technology careers. Such a finding was only revealed because of the triangulation strategy.

Member checking is a strategy to achieve validation that usually happens after data analysis; however, in this study, a similar approach was used during the interviews (Punch and Oancea, 2014). The researcher asked the interviewees, on several occasions, to *confirm* whether their accounts and perspectives had been accurately understood and/or interpreted by the interviewer/researcher. According to Hamilton and Corbett-Whittier (2014), such strategy is 'advisable to summarise the key points the respondent is making and ask for confirmation that this is an accurate synopsis, or you can reiterate a key point back to the interviewee' (p. 136).

4.5.2.3. Confirmability

For Benaquisto and Given (2008), confirmability 'reflects the need to ensure that the interpretations and findings match the data, that is, no claims are made that cannot be supported by the data' (p. 896). In other words, confirmability is related to the findings and whether they are based on research goals without being altered directly by the researcher (Hamilton and Corbett-Whittier, 2014). Triangulation of data and triangulation of participants' perspectives (as detailed further in Section 4.5.2.1) were also used as strategies that aimed at increasing this study's confirmability. Regarding research methods, Thomas (2013) argues that:

[A]nother analytic method may make you decide to reject an explanation that you had come up with from your first analysis of findings. Or it may encourage you to have more confidence in the explanation you proposed on the basis of your first analysis (p. 146).

According to Lincoln and Guba (1985), one of the best strategies to increase confirmability is the creation of an *audit trail*, that is, allowing another auditor to

examine the processes and findings of a study. Raw data (audios, documents), products of data reduction (fieldnotes, interview notes), products of data reconstruction (case reports), and process of notes (methodological decisions) related to this project will be available to the public and for external audition after the project has concluded at the University of Edinburgh Research Database.

4.5.2.4. Dependability

For Zucker (2009), dependability is a manifestation of the researcher's processes being consistent and reasonably stable over time and across researchers and methods. Hamilton and Corbett-Whittier (2014) proposed that 'the clearer your outline and justification of research procedures, the greater the degree of dependability which can be ascribed to your work' (p. 137). According to Benaquisto and Given (2008), dependability accounts for the contextual changes that can affect research design, which demands from the researcher to be conscious of such changes and act accordingly. Thomas (2013) defines reliability (another surrogate for the same concept in qualitative research) as 'the extent to which a research instrument will give the same result on different occasions' (p. 138).

Three strategies were used in order to enhance dependability within this inquiry: (1) the researcher was both the primary and the secondary coder (refreshment of perspective); (2) the stipulation of the *theoretical framework as primary codes* used to analyse the raw data, at the beginning of the research process; and (3) the creation of an *audit trail* of the entire data analysis process of the three case studies. Although the Inter-coder agreement (ICA) seems to be the most used element of dependability in qualitative research (see Benaquisto and Given, 2008; Kirk and Miller, 1986; Silverman, 2013), in this inquiry, only one researcher was responsible for the fieldwork and, therefore, for the primary and secondary coding. Having been able to perform the primary coding and, after some time, to review and perform the secondary coding enabled a refreshment of perspective and avoid 'distorting effects immersion in the data can cause' (Guest et al., 2011, p.92).

The process of coding considered the data that originated from all the gathering methods that had been applied. The primary coding was conducted in November of 2015 whereas the secondary coding took place in January of 2016. The secondary coding confirmed the codes that had been established during the primary coding,

since almost no alterations were necessary to be done to the codes related to the SCCT theoretical framework. Nevertheless, new codes emerged during the secondary coding (e.g. genre and career interest, family pressure and career interests towards non-technology careers). Due to the appearance of those new codes, a third round of coding was conducted between December/2015 and April of 2016.

Another strategy adopted to help enhancing dependability was the stipulation of the theoretical framework as primary code during the initial data analysis process (e.g. Mani, 2004; Ritchie and Lewis, 2003). One of the reasons why the secondary coding, during the process of data analysis, presented almost no changes in comparison to the primary coding was the use of a set of pre-defined codes originated from the SCCT theoretical framework (Lent et al. 1994). This set of codes established an understanding about the meanings of concepts from the data collected (e.g. statements, documents, notes). For example, one of the codes which had been pre-coded was “self-efficacy”. Thus, sets of questions were created to address the development of self-efficacy stemming from ER learning opportunities based on previous self-efficacy questionnaires (Nugent, Barker, and Welch, 2014; Robinson, 2014). During the process of data analysis, the self-efficacy domain for each individual case was built through the set of analysed data labelled under the code “self-efficacy” and related to the participant in question (combination of data regarding subject – individual case – and object – self-efficacy).

The last and third strategy used to enhance dependability within this study was the adoption of an audit trail involving the three case studies. According to Benaquisto and Given (2008), an audit trail can demonstrate accountability throughout the research process. In this inquiry, the creation of an audit trail enabled (1) the understanding of aspects related to the research itself; and (2) the accountability for changes within the research design and process of data analysis. The next section focuses on the unit of analysis on which this study was based.

4.6. Units of Analysis

According to Hamilton and Corbett-Whittier (2014), there are eight key elements that characterise a given study as a case study – amongst which subjects and case objects (p. 11). For Thomas (2013), the case subjects are the cases themselves

whereas 'the object is the analytical frame (...) which the subject is in some way exemplifying and illuminating' (p. 151).

In this study the case objects are the development of career interest towards technology which is analysed through the lens of SCCT as the theoretical framework (Lent et al., 1994) and the development of technology skills. Thus, the units of analysis for career interest comprised the SCCT constructs that underpinned the development of career interest – self-efficacy; outcome expectations; interests; confidence; choice goals; barriers; and supports (Lent et al., 2002). In order to establish if the cases studied were able to provide students with opportunities to develop technology skills, a framework was established taking into account: 1) the national education context where this study was undertaken; and 2) international guidelines or parameters that establish the implementation of technology skills in Primary and Secondary Schools. This framework was then used to compare with each case study curriculum and data triangulated from students', teachers' and mentors' perspectives to establish the frequency these skills were available and through which ER approaches. The process of development of such a technology skills framework is further discussed.

4.6.1 A framework to establish the presence of opportunities to develop technology skills

In Brazil, it is the responsibility of the Ministry of Education to provide the curriculum guidelines for all disciplines in public Basic Education (see Chapter 3). These guidelines, however, are found to be outdated (França and Tedesco, 2015). As a consequence, Brazil has been remaining on the fringe of the international debate about digital literacy, digital inclusion and computational thinking implementation in the curricula for Basic Education, although some researchers have suggested changes in that sense (Barcelos and Silveira, 2012; França and Tedesco, 2015). Current parameters still refer to use of digital education technologies in schools in association with ICT's whereas important technological changes, such as the use of the internet, are not addressed in current National Curriculum Guidelines (MEC, 2000). Despite not having been included in the guidelines, ER was considered, since then, a meaningful digital technology to be used in Education. For at least ten years, ER groups throughout Brazil have been promoting independently technology skills, digital literacy and computational thinking (e.g. Junior et al., 2010; Paula, 2017).

The lack of updated national parameters for the development of technology skills in Basic Education posed an issue for this research: how to determine which technology skills would be relevant? And how the existence of an international debate about the implementation of computational thinking in Primary and Secondary Schools could contribute to the development of this framework? The strategy used in this study was to identify the technology skills which competent international bodies considered important to be present in Primary and Secondary School curriculum. After that, an expert in the computer science field helped to refine the technology skills chosen from those sources, according to the study participants' level of education.

The set of technology skills used to compare to those developed at each educational setting was informed by the following sources:

- (1) skills suggested to be developed by five curriculum guidelines for ICT or Computer Science courses (ACM, 2013; Anderson (Ed.), 2002; Caspi et al., 2005; MEC, 2012; Naace, 2012);
- (2) suggestions found in bodies of literature which had been indicated by experts in the field specifying the skills expected to be developed in Primary and Secondary Schools; and
- (3) the Brazilian guidelines for curriculum development (PCNs) regarding the implementation of technology skills within the National Basic Education (MEC, 2012).

The similarities and differences between the sets of technology skills on which the curriculum at each educational setting had been based were highlighted. Twelve common technology skills were found to be part of the curriculum guidelines developed within all the investigated contexts. A table containing the technology skills stemming from the curriculum guidelines for ICT and Computer Science was submitted to a professional with a background in both fields, Education and Computer Science. After having received feedback regarding the table of common technology skills, three of the twelve skills – commitment to life-long learning (exclusively seen in the ACM guidelines), entrepreneurship, and appreciation of domain-specific knowledge – were excluded from the analysis because they had been found in only one curriculum or because they were incompatible with the participants' Education levels. Table 4.2 presents the final set of skills which were investigated in this study.

Table 4.2: Investigated technology skills

SKILL	DESCRIPTION
Technical understanding of technology used in educational robotics settings	Technical knowledge of ER and related areas which each ER setting is developing. E.g. In a school where ER and digital games are being developed, students should be able to understand (1) common concepts in ER such as engineering and programming; and (2) digitalization and upload.
Familiarity with common themes and principles	Recognizing that working with ER involves understanding several recurring themes such as teamwork, programming, project, interdisciplinarity.
Appreciation of the interplay between theory and practice	Understanding the connection between theory and practice.
System-level perspective	Thinking on multiple levels of detail and abstraction (research, design, build, analyse, presentation).
Problem solving skills	Application of their knowledge to solve real-world problems (considering that ER projects are usually designed to show a solution in a small scale).
Project experience	Involvement in at least one substantial project (considering their ages, i.e. robotics challenges, science fairs, school and personal projects).
Commitment to professional responsibility	Students should be able to recognise the social, legal, ethical, and cultural issues inherent in ER educational settings.
Communication and organizational skills	Students should be able to make presentations explaining their solutions, developed accordingly to each pedagogical approach, using a broad range of media and involving face-to-face, written and/or electronic communication.
Awareness of the broad applicability of technology	Awareness of the broad applicability of ER and its technologies including recognising the role that technology can play in the process of developing knowledge in other areas.

A set of specific bodies of knowledge, that varied according to the educational settings, was also identified in this study through the same criteria on which the set of technology skills was based. Topics such as robot assembly, ER project development and how to use sensors were expected to be mastered after six and eighteen months by the participants of Case Study 1 and the participants of Case Studies 2 and 3, respectively. The description of the technology skills for each case study stemmed from the analysis of (a) activities developed within each educational setting; (b) the participants' accounts on the matter; and (c) documents.

The National Curriculum Guidelines (MEC, 2000b, pp.61–62) proposes that the development of technology skills can occur 'through practical experiences', since the understanding of main concepts and themes related to technology, as well as knowledge building, can take place. In this sense, this study investigated the development of technology skills related to practice with technology (technical understanding, familiarity with common principles and themes, appreciation of the interplay between practice and theory, problem-solving, project experience, communication and organisation, and system-level perspective). It also investigated

the recognition of the impact of technology development through commitment to professional responsibility and awareness of the broad applicability of technology.

4.7. Methods for Data Collection

Several stages of data collection were necessary to develop this study and all data collection methods supported triangulation during the process of data analysis. This section presents the methods of data collection which was applied to this study. The following methods were used for data collection: (1) semi-structured interviews with students, mentors and teachers who were part of the ER groups within the selected educational settings; (2) students' electronic journals (Blogs) which were exclusively used in Case Study 3; (3) observations of ER Robotics classes, competitions and development of projects, for Case Studies 1 and 3, and observation of Robotics classes and project development for Case Study 2; (4) document review (analysis of projects and papers produced by the students and their teams alongside written feedback of judges stemming from competition participation); (5) researcher's fieldnotes. Participants' demographics included students' ages, gender, grades, roles within the ER groups, length of time of their participation in the ER groups and access to technology at home.

According to Merriam and Tisdell (2015), case studies qualify as qualitative research, especially when the researcher is interested in understanding a complex process or phenomenon. In order to do that,

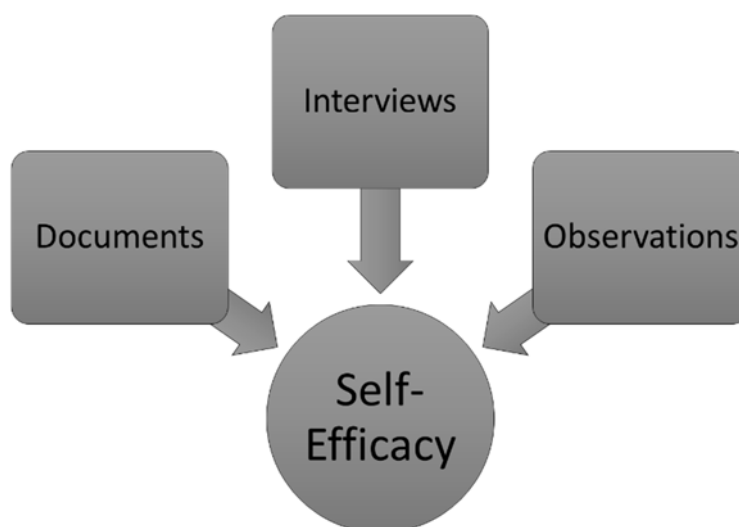
Unlike experimental, survey, or historical research, case study does not claim any particular methods for data collection or data analysis. Any and all methods of gathering data, from testing to interviewing, can be used in a case study, although certain techniques are used more than others (Merriam and Tisdell, 2015, p.42).

In this sense, the methods of data collection used in this study aimed to provide increasing levels of information about the phenomenon (triangulation of data and perspectives), to the point where saturation would be reached (Hamilton and Corbett-Whittier, 2013). As previously discussed, (see previous sub-chapter), the SCCT model of career interest provided the framework that allowed the development of units of analysis of this investigation. Therefore, the choice of methods of data gathering chosen were informed by the units of analysis and the

research questions, as well as the constraints provided by the environment and subjects that were part of the investigation.

Five methods of data gathering (interviews, blogs, observations, document interrogation and fieldnotes) were used in this study. However, not all the methods of data gathering were able to help in providing information in the process of triangulation and saturation of data for each research question. For instance, to understand which barriers became a factor in the development of interest towards technology careers, data stemming from interviews, observations and fieldnotes were useful in all case studies. Nonetheless, blogs were added to these methods to better investigate the units of analysis in case study 3. Document interrogation did not provide helpful data to understand which barriers were a factor affecting the development of interest towards technology careers. The figure below represents the equal importance of these methods in providing answers to the research question regarding self-efficacy.

Figure 4.1 – Methods contributing to respond the research question about self-efficacy



4.7.1. Interviews

An interview in educational research is a 'discussion with someone in which you try to get information from them (...) (being information) facts or opinions or attitudes or any combination of these' (Thomas, 2013, p. 194). Both semi-structured and structured interviews were key methods of data collection which were used at

different times in this study. Semi-structured interviews 'combine the structure of a list of issues to be covered together with the freedom to follow up points as necessary' (Thomas, 2013, p. 198). Semi-structured interviews assessed the participants' perceptions on self-efficacy beliefs, outcome expectations, choice goals and interests, barriers, supports, attitudes towards technology, and the work market. The same template of questions was used for all interviews (see appendix III). The interviews were conducted in two stages:

- (1) the Case Study 3 participants took part in online interviews before (December of 2014) and after (January of 2015) their participation in the regional FLL. Data collection also involved their experiences during the MNR; and
- (2) Those participating in Case Studies 1, 2 and 3 were interviewed face-to-face during the fieldwork period (between 26/10/2015 and 13/11/2015).

All the participants were interviewed online between December/2015 and April of 2016 after having participated in ER projects, competitions and classes. The challenges and differences between these different types of interviews are further discussed in Sections 4.7.1.2. and 4.7.1.3). The next section details the pilot study which was developed by the end of 2014 in order to implement and refine study protocols (Yin, 2009).

4.7.1.1. Pilot study

The pilot study involved the two investigated educational settings and was conducted before the fieldwork. Such strategy enabled the development of interview skills, confidence with the use of technology by participants and responsiveness. Thus, when the online interviews were conducted in 2015, complications (such as those related to technology) did not influence the interviewing process itself, since a positive rapport between interviewer and interviewees had been previously built.

On 17 November 2014, a study protocol (Hamilton and Corbett-Whittier, 2013) underpinned by the SCCT model of career interest was developed. This strategy was important because it allowed the reorganisation of the design when it is necessary as well as allows the monitoring of all steps in research increasing reliability (Yin, 2009). The study protocol was also an important opportunity to learn how to develop the rationale for this particular case study. It was possible to

understand how the interaction between literature review; research methodology and ethics considerations works.

Learning with the study protocol application also helped me start the process of data collection and analysis. Findings and application of the study protocol have been discussed during meetings with my supervisor, generating several modifications in my study, such as the choice of sampling group, location of the cases to be further studied, timetable, ethics issues, gatekeepers, and other important topics.

Having been able to practice the interviews – especially those that were going to be conducted online – during the pilot study also allowed the participants to feel comfortable with the technology to understand the advantages of online interactions. The semi-structured interviews focused on the topics referring to the theoretical framework and the main theme of the study (the development of technology skills and career interest towards technology stemming from the participation in ER groups). Moreover, further themes which were raised by the participants were addressed.

4.7.1.2. Online interviews: enhancing privacy and addressing ethical procedures on qualitative research

Online interviews have been increasingly used in qualitative research for the past two decades (e.g. Cater, 2011; Farooq and de Villiers, 2017; Janghorban et al., 2014; Salmons, 2012; Sullivan, 2012). Online interviews were applied as a method for data collection because of their cost-effective nature and their effectiveness in allowing the researcher and the participants to overcome the distance between them. According to Iacono et al. (2016), researchers conducting online interviews should follow the same ethical procedures identified by Plummer (2001): (a) intellectual property; (b) informed consent; (c) right to withdraw; (d) unintended deception; (e) accuracy of portrayal; (f) confidentiality; and (g) financial gain. The decision to conduct online interviews was informed by the research design which aimed to examine thoroughly the extent of interest towards technology careers developed through time. Since the researcher was based in a different country than that of the participants and the technology was available, the method was added to the data collection stage.

The main disadvantages of using online interviews are related to confidentiality, anonymity and privacy (Cater, 2011; Sullivan, 2012). In order to address Plumer's ethical procedures, a research plan including the use of private group chats (protected by password, anonymous and encrypted) was designed. Such virtual spaces (such as Google groups), which are considered suitable for qualitative research, were suggested as the first option to those within the educational settings who had been invited to participate in this study (Janghorban et al., 2014; Sullivan, 2012). Students would have received "dummy accounts" through which they could have remained anonymous. Interviews would have been conducted individually in a room in which a trained teacher would have assisted technically the participants before and after the periodic interviews. However, after having explained the hypothetical scenario where the interviews would have occurred online, the teachers recommended the substitution of closed groups for VoIP (Voice over Internet Protocol) apps, such as Skype or Google Hangouts. Two factors motivated that request from the participants: (1) the fact that they were more familiar with the VoIP-related technologies; and (2) previous cases of difficulty involving user names and passwords (essential in using closed chat groups) by the participants.

Besides being a fairly new type of technology in qualitative research, the use of VoIP apps presents advantages and disadvantages. It allows the researcher(s) to overcome long distances and time constraints as well as to develop longitudinal studies and (Janghorban et al., 2014; Sullivan, 2012). Farooq and de Villiers (2017) argues that it is more advantageous than telephone interviews – especially when the interviewees are younger participants, since VoIP is a more current technology than telephone calls. However, both technical and ethical disadvantages of using VoIP-conducted interviews as a data gathering method in qualitative research have been addressed in the literature regarding the matter.

In terms of technical disadvantages, Cater (2011) argues that elements such as body language and rapport building can be more difficult to read and/or analyse during an interview conducted via VoIP than during a face-to-face interview. For Farooq and de Villiers (2017), the lack of visual cues might become a problem. As for ethical disadvantages, privacy cannot be guaranteed due to certain companies' terms of use and conditions and, therefore, issues related to the disclosure and participation withdrawal can easily emerge (Iacono et al., 2016; Sullivan, 2012). Nevertheless, researchers have been indicating strategies that aim to enhance privacy within the

use of Skype in qualitative research (e.g. Cater, 2011, 2014; Farooq and de Villiers, 2017; Iacono et al., 2016).

On one hand, in the terms of use, Skype, for example, claims that data shared between users are encrypted (Iacono et al., 2016). On the other hand, audios and videos are claimed not to be reviewed by the company, even though personal information and files shared between users are said to be potentially reviewed for the purposes of assuring that users have not infringed third party copyrights, or shared illegalities (Iacono et al., 2016). This should not be considered an issue as long as the participants are well-informed. The following strategies were suggested, and, eventually, not applied due to the participants' request, to protect the participants' anonymity during the Skype interviews:

- (1) the creation of new Skype accounts, one for each Case Study, containing the minimum necessary of personal data to be discontinued at the end of the data gathering stage; and
- (2) the participants would be addressed by their pseudonyms during the interviews.

All the standard ethical procedures which are suggested by Plummer (2001) were observed, added to the research plan, agreed upon by all the involved parties, approved by the Ethical Committee at the University of Edinburgh and applied. Before having signed the consent forms, teachers leading the ER groups at the investigated educational settings had a meeting with the participants and their families in order to explain the research procedures. Time was given for the participants to read the consent form and ask questions about any unclear issue. The importance of protecting one's privacy and personal data when using the internet was addressed as well as the ethical issues involving the use of VoIP. Moreover, the possibility of having private conversations reviewed and/or stored by Microsoft® or third-party companies, such as government agencies, was explained (Microsoft, 2016). It was also informed during the same meeting that the interviews were going to be audio-recorded and about their rights to withdraw their participation at any stage of the research. A timetable was made available for the potential participants and their families containing the period during which the researcher would be present at the educational settings.

4.7.1.3. Online interviews: focus group

Online focus group interviews provided a *follow-up* on individual cases regarding the development of interests and skills, which aimed to understand the impact of the ER approaches in the development of career interest towards technology. Gubrium and Holstein (2002) suggest that focus group interviews have become a valid and largely accepted qualitative research method. It involves collecting data from the interaction of a group over a subject which is determined by the researcher or that arisen from that proposition (Gubrium and Holstein, 2002).

Morgan (1996) compares focus groups as a research method to participant observations and interviews. He argues that focus groups have the strength of 'relying on the researcher's focus'; hence, the potential of being able to produce data focusing on the researcher's topic of interest (Morgan, 1996, p.13). In that sense, online focus group interviews were conducted via Skype; however, disadvantages, such as the impossibility of focusing on physical cues, were experienced due to limitations stemming from camera framing (Cater, 2014; Sullivan, 2012). In order to minimise those disadvantages, other interviews were conducted. The participants were interviewed individually – face-to-face by the end of 2015 and via Skype in the beginning of 2016 – to reaffirm their perspectives on a given topic.

This section has focused on the interview as a method for data collection. The next section discusses another source from which data were collected for this study: online journals (Blogs).

4.7.2. Online Journals (Blogs)

The inclusion of password-protected online journals within all three case studies was part of the original research plan. However, time restriction and difficulties of ensuring that students would have posted entries in a regular basis led to changes. Since those participating in Case Studies 1 and 2 were not able to contribute to the study through the development of Blogs, observation was applied as a method for data collection. The Case Study 3 participants, in turn, used the Blogs in a way that allowed data to be collected from their journal entries (see Section 4.9 for further details).

The data was collected from Blogs that had been developed by the teacher (ER Group Blog) and the students (which were linked to the teachers' Blog and aimed to present the students' perceptions regarding the activities developed within the ER Group). The participants' Blog entries between July of 2015 and April of 2016 were collected and stored in the Nvivo software through Ncapture – a tool that converts html pages into Portable Document Format (PDF) files. For example, participants used their individual Blogs to write about their views on the first Robotics classes that they had had in the beginning of the year or about the topics they wanted to choose for their presentation during the FLL 2015/16. Both the software and the Blog data were stored in a password-protected hard drive to which only the researcher had access.

The teacher participating in Case Study 3 published at least one Blog entry per week containing a summary of everything that the students had done, including the stages of each project, preparation for challenges and descriptions of ER classes. Since 2007, students had been invited to create their own Blogs to share what they had been learning to their parents and the school community. For that reason, both the students' and the teacher's Blogs were rich sources of data that allowed the possibility to explore, amongst others, (1) which learning experiences had been conducted; (2) which technology skills had been learned; and (3) the students' perceptions about their experiences within the ER group. For example, on 22/08/2015, the teacher participating in Case Study 3 posted the following entry about the Brazilian Robotics Olympics:

The FLL is a Robotics challenge that will occur between November 6 and 7, this year, and in which several schools will participate. The theme for this year's challenge is "How to manage the urban trash produced in our cities?" or "FLL Trash Trek". We started to prepare our group of students with the official 2015's challenge mat.

Case Study 3 teacher

The teacher's summary of the preparation activity was illustrated by more than 20 pictures showing the students receiving the FLL preparation material followed by the assembling process of those parts and the initial training. Through her post, it was possible to have an overview of which material the team had available to prepare for the challenge and the time that they had to practice before the event (three months).

A similar process happened to the students' entries, such as the following which had been written by Andrew:

On 22 August, our robotics team went to Sao Leopoldo City to participate in the OBR. We did well because we didn't have any fights or arguments between our team members. In our team, there was Peter, Donna and Daniel. Our team's performance was good, in part. I learned that things don't always work ok on the competition day. I also learned new ways to develop our code and build our robot. It was a good experience because I met new teams and new people. We could have done a better performance, though, which would have allowed us to be classified for the Nationals.

Andrew – Case Study 3 participant

Andrew's entry presented his perceptions about learning experiences that he had had alongside his teammates during the OBR/2015. The participants' (students' and teacher's) entries were analysed through the lens of the theoretical framework – SCCT – informing this inquiry. The documents that were reviewed for this study had to be, firstly, translated to English and, then, analysed according to the set of codes that had been previously developed for analytical purposes. For that reason, when codes such as self-efficacy, choice goals or technology skills arose from data, it was possible to allocate that information in an individual framework of development of career interest towards technology.

Although considerably new, the use of online journals as a source for data collection have been related to inquiries about educational technologies and participants' behaviour online (Harricharan and Bhopal, 2014). In this investigation, online data regarding participants' perceptions about development of skills, career interest and vocational behaviour were collected to allow a better understanding of the Case Study 3 participants' experiences with ER. Ethical procedures to enhance privacy and confidentiality were suggested (such as the creation of closed groups – e.g. Google Blogs – and/or the use of “dummy accounts” to provide users' anonymity to users). However, the participants and their families requested to continue using their own Blogs, despite the best attempts to convince them otherwise.

One of the reasons for the recommendations to have been denied and, therefore, not been fully applied, was related to the “tradition” within that educational setting and its community in sharing the students' learning experiences with their parents

through Blogs. It was necessary to understand and accept the community and the participants' requests, without failing to implement the needed ethical procedures, in order to maintain the positive rapport that had already been built. Regarding such issue, Gubrium and Holstein (2002) argue that:

[D]ifferences in culture and power make researchers' attempts at reciprocity especially challenging. What may be culturally appropriate in one context may not be in another. Also, any attempt to affect change by researchers who hold greater power due to their ethnicity and/or social class may be viewed negatively by others (p.212).

This section has discussed the use of online journals as sources of data. The next section focuses on participant observation.

4.7.3. Participant Observation

According to Merriam and Tisdell (2015) observations are:

[C]onducted to triangulate emerging findings (...) used in conjunction with interviewing and document analysis to substantiate the findings (...) and to provide some knowledge of the context or to provide specific incidents, behaviours and so on that can be used as reference points for subsequent interviews (p. 119).

Benaquisto and Given (2008) argue that participant observation is particularly suitable for the studies of social phenomena which have not been thoroughly investigated yet and where the behaviour of interest 'is not readily available to public view' (p. 598). In this study, participant observations were combined with semi-structured interviews in an interactive process of categorisation which aimed to frame an in-depth picture of each investigated ER group. When observations occurred, the researcher's activities had been known to the group and had been subordinate to the researcher's role as participant (Merriam, 2015). A trade-off was expected between the researcher and the participants, since a certain level of trust and confidentiality had been established.

The initial research plan delimited the role of and time spent on observation, since the focus would be on data gathering through the semi-structured interviews. However, the Case Studies participants representing the teachers' and mentors' groups offered time slots during which longer and more often observations could

happen. Hence, it was possible to observe the ER classes and the ER projects being developed within all the educational settings. Table 4.3 summarises the observations log.

Table 4.3: Summary of the Observations

CASE STUDY	Dates/Observed ER Approach	Participants	Observed Behaviours and focus of the method
CESMAR Socio-educational Course	27/10: ER class 28/10: ER class 03/11: ER project 13/11: ER project	Students and Teachers	Emotional and physical responses to problem-solving contexts;
CESMAR Electro-electronics Course	30/10: ER challenge 05/11: ER classes 06/11: ER classes 09/11: ER projects 10/11: ER projects	Students, Tutors and Teachers	Application of technology skills/new technology skills developed during the last six months or more; Description of the ER approaches undertaken;
EMEF José Mariano Beck	04/11: ER challenge and ER projects 09/11: ER challenge and ER projects 11/11: ER challenge and ER projects 12/11: ER challenge and ER projects	Students, Mentors and Teachers	Gathering information about possible factors of barrier (such as negative peer interactions or lack of infrastructure) and factors of support (positive peer interactions or availability of needed infrastructure)

At least four observations of different learning experiences were conducted within each case study. At the setting where the Case Study 1 was undertaken, observation of an ER challenge was not possible due to the ER group timetable (learning experiences dedicated to the ER challenge had been allocated to April of the following year, 2016, when the data collection stage of this study had already been concluded). At the setting where the Case Study 3 took place, in turn, observations of ER classes were not possible, since such activities would be developed at the beginning of each year. At the setting where the Case Study 2 was conducted, however, all three ER approaches could be observed. Such achievement was possible due to the fact that the researcher's timetable and the ER group schedule had coincided as follows: (1) participation in the MOSTRATEC Robotics challenge (29 and 30/10/2015); (2) participation in the ER classes (05 and 06/11/2015); and (3) participation in the ER project developed as the final and mandatory activity of the course (09 and 10/11/2015).

Participant observations in this study allowed the collection of data regarding behaviours and learning experiences which were developed within each educational setting. The data collected through unstructured observation enabled reflection upon the vocational behaviours that had been observed and the practical application of previously learned knowledge. Moreover, it was possible to grasp the idea of how learning experiences had been conducted. Such information contributed to the

process of building a framework about the development of vocational interest towards technology careers and the potential development of technology skills in the students participating in the three case studies.

This section has discussed the participant observation as a source of data. The next section focuses on document interrogation.

4.7.4. Document Interrogation

For Merriam (2015), documents 'refer to a wide range of written, visual, digital, and physical material relevant to the study at hand' (p. 139). ER courses syllabi, ER project plans and written feedback from judges during the ER competitions were gathered for document interrogation within this study. Such documents clarified the understanding of the objectives set out within each investigated educational setting and the extent to which the teams had (a) achieved their goals; (b) understood the topics; (c) developed technology skills; and (d) seized the provided opportunities for personal improvement. Document interrogation was used to triangulate data about the possible development of technology skills and career interest towards technology stemming from the participation of students in ER approaches. Table 4.4 presents the main purposes for the use of document interrogation for triangulation of qualitative data.

Table 4.4: Summary of Document Interrogation

Type of Document	Participants involved	Purposes
Feedback from FLL judges (e.g.: FLL 2014 feedback on the presentation of team's robot)	Case study 3 participants (students and teacher)	Gathering information about the development of technology skills;
ER Projects' descriptions (e.g.: article submitted to the MNR Exhibition about the robotics project developed by case study 3 participants)	Case study 1, 2 and 3 participants	Gathering information about the development of career interest towards technology
Courses Syllabi	Case Study 1 and 2 participants (Teachers)	
ER lesson plans	Case study 1, 2 and 3 participants (Teachers)	

Documentary data provided relevant information about the development of skills within each case study; moreover, they indicated the topics related to each ER approach that had been addressed by the curriculum. Such data was, then, compared to the participants' perceptions, collected through interviews and online

journals on the development of their own skills and interests, according to the SCCT model (Lent et al., 2002). As a result, a framework of the extent of interest towards technology careers and technology skills which had been developed within each case study was built.

This section has focused on document interrogation as a method through each data can be gathered. The next section addresses the last source of data collection used in this study: the researcher's fieldnotes

4.7.5. Researcher's Fieldnotes

Schwandt (2011) argues that the definition of fieldnotes has widely varied within the literature on the matter and that fieldnotes are not usually considered as an actual source of data related to the phenomenon being observed. However, for Schwandt (2011), fieldnotes are useful tools for the researcher(s) conducting fieldwork during the analytical stage of the study. He also argues the following:

There is no standard definition of field notes, their form, or content, however. Some fieldworkers define field notes as 'raw' data or material—notes made in the field based on observations and conversations, rough diagrams and charts, lists of terms, and so on. These kinds of notes are very much prepared for an audience of one—the fieldworker—and thus are individualistic and personal and reflective of the unique ways individual fieldworkers conduct fieldwork'. (Schwandt, 2011, p.116)

Hamilton and Corbett-Whittier (2013) highlight that the use of fieldnotes 'provides an additional layer of reflective commentary or it can simply reflect factual data; much depends on how you view research and notions of objectivity and subjectivity' (p.96). Fieldnotes were used in this study to provide the researcher's perspective regarding the development of technology skills and to register behaviours and factors (barriers and supports) which were noticed when fieldwork was being conducted. Adding a reflection layer to the process of data analysis helped to respond to each research question related to development of interest towards technology careers and technology skills. For example, triangulation of data originated from fieldnotes (1) allowed the comparisons of factors influencing the development of career interest, such as barriers; (2) indicated convergences and divergences between the collected data; and (3) enabled a clear explanation for the findings. Table 4.5 summarises how

the fieldnotes were used in this study and their relationship with the research questions.

Table 4.5: Summary of Fieldnotes

Fieldnotes	Purposes
Researcher diary written during fieldwork from 28/10/2015 to 15/11/2015	<p>Gathering information about possible barriers and supports which could moderate the development of interest towards technology careers to compare to data originated from other methods;</p> <p>Gathering information about the strengths and weaknesses of each ER approach developed and observed for further comparison;</p> <p>Gathering information about the possible development of a broad vision on the technology job market to compare to data originated from other methods.</p>

As Benaquisto and Given (2008) and Merriam (2015) suggest, fieldnotes were written while the observations were taking place or immediately after. The goal was to create a systematic researcher's journal with first impressions about what had just been/was being observed and to register a description of the observed activities. In so doing, the fieldnotes helped the focus to be on the research questions and guided the reflections to be about the potential development of behaviours related to career interest and development of skills.

This section had presented a comprehensive discussion about the methods through which data was collected for this study. The next section addresses the data analysis procedures.

4.8. Data Analysis Procedures

Hamilton and Corbett-Whittier (2014) argue that there are several ways to frame data during the data analysis process. The method used in this study was informed by the theoretical framework (SCCT) and the research questions. For example, SCCT informed the *pre-coding* process of data gathered and the discussion of findings, since such framework had guided the research questions on which the research design had been based. Thus, data originated from interviews, fieldnotes and observations could be analysed through codes such as *self-efficacy* or *barriers*, which are concepts belonging to the SCCT model that underpinned the investigation.

Although the focus of the analytical process was on the emergence of the codes preestablished through the SCCT theoretical framework, the researcher did not

disregard unanticipated themes emerging from the data (Hamilton and Corbett-Whittier, 2014). In so doing, the process of data analysis became similar to what LeCompte and Schensul (1999) describe as an exercise that allowed the 'researchers to make rough descriptions of a population in a relatively short period of time by showing how many people fall into each category of a given code' (p. 66). Thus, the conceptual frame was used as a strategy to analyse data and help to delineate and organise themes arising from the collected data.

Yin (2009) suggested protocol for data analysis had been previously tested with the Case Study 3 participants during the pilot project (Paula et al., 2015). Such practice helped the development of the final research design, which (1) improved the aspects related to adequacy of questions to the participants' ages; (2) enabled the addition of research methods; and (3) allowed the adaptations of the ethical procedures to accommodate the online interviews. Each step that had been taken in the process of data analysis using multiple data gathering methods, from the creation of a data analysis protocol to the conclusions regarding within-case analysis and the research questions proposed in this inquiry are detailed in the following sections. As an example to illustrate the data analysis process, some findings from the Case Study 2, which had been conducted within the CESMAR Electro-electronics course, are presented.

4.8.1. Translation and Coding

Firstly, all the data that had been collected through different methods were transcribed and, then, translated from Portuguese to English. A feature of the NVivo software named "transcribe mode" was used to combine the translation process to the data analysis as suggested by Bazeley and Jackson (2013). Secondly, the SCCT theory was used to *precode* the collected data, that is, the main concepts related to the SCCT that explain the development of career interest were used to create a table of reference (See Figure 4.1) to help in the process of data coding. Such table of references was fed to the qualitative data analysis tool NVivo, which allowed the process of precoding to be applied to the collected data that had been already saved and translated. As a result of the analysis, themes derived from SCCT, such as *self-efficacy*, alongside quotes/references derived from the gathered data.

Unexpected themes, which were unrelated to the SCCT model, stemmed from the data and were added to the table of codes and connected to the quotes/references. The pre-defined *codes* (or *nodes* as named within the NVivo Software) from the SCCT model included (but were not limited to): (1) self-efficacy; (2) outcome expectations; (3) choice goals; (4) choice actions; (5) development of interests; (6) ER approaches; (7) learning opportunities; (8) contextual affordance; (9) structures of opportunity and support systems; and (10) barriers. Themes (codes) which emerged from the process of data analysis included (but were not limited to): (1) entrepreneurship; (2) hero role model; (3) interdisciplinarity; (4) peer interaction; (5) technology skills development; (6) family influence towards literacy; and (7) interest in a field unrelated to technology. Figure 4.1 presents the codes used in the pre-coding process and exemplifies the codes which stemmed from different stages of the data analysis process.

Figure 4.1: Nodes used for precoding and stemmed from data

Nodes	
Name	
Opportunity for Skills	
Outcome expectations	
peer interaction	
Person inputs	
Personal Development	
Pre-existing interests	
Previous and weekly activities	
previous knowledge about technology careers	
Previous technology knowledge	
roboduino	
Scholarship	
Self-efficacy	
self-motivation	
STEM Skills development	
Student's experiences influencing relatives and or friends	
Supports	
teachers	
technology skills development	
weekly activities	

A top-down analysis was used in the interview transcripts that had been translated and saved in the NVivo project file alongside all the other documents, interviews, and audios. In a top-down analysis, the theoretical framework guides the researcher's attention to the specific domains of interest within the inquiry (LeCompte and Schensul, 1999). Each translated transcript was analysed through a line-by-line

process. The interviews were placed in pre-organised domain blocks according to the SCCT and, when a statement would reflect the domain, the researcher highlighted the sentence(s) related to that domain/code (e.g. self-efficacy) and stored them as part of the domain code at the NVivo Library for the project. Themes and domains which were not related to the SCCT domain were stored as new codes and were part of the analysis.

4.8.2. Identification of the factors explaining each SCCT domain

The second step consisted of identifying the factors that could explain each SCCT domain. For example, in the self-efficacy domain, the SCCT model emphasises four main sources of self-efficacy: (1) mastering learning experiences; (2) vicarious learning provided by social models; (3) social persuasion, in which a person is verbally persuaded that possesses the capabilities to master given activities; and (4) positive emotional and affective states felt during the performance of a specific action. A second and third round of analysis of the same transcripts, at times, led to the division of the factors into sub-factors. For example, a participant could have identified himself/herself as capable of programming robots or building a robot using an ER kit, which would, therefore, add to the self-efficacy category in terms of actions on which the participant had identified to be self-efficient.

4.8.3. Identification of the factors that could lead to the development of career interest towards technology in the individual level

Each domain was verified through the triangulation of sources (interviews, documents, observations, fieldnotes.) and viewpoints (participants', teachers', mentors'). Thus, if a participant claimed to have developed self-efficacy towards programming, for example, that piece of information was triangulated with other sources (teachers' and/or colleagues' perspectives; observations; and/or documents). After having confirmed or refuted the information, that finding would be added to the list of SCCT domains which had or had not been developed by the participant. Although such process was developed on different occasions within case study, every time data was collected, information would be added to the files of the

participants. That procedure facilitated the confirmation whether the participants had developed the SCCT factors. Table 4.6 presents the SCCT factors and how they related to the findings.

Table 4.6: The relationship between SCCT domains and findings

Self-efficacy factors	Findings
(1) Personal performance accomplishments	Positive SE beliefs towards engineering skills and engineering activities (e.g. welding, designing, projecting, robotics development); The participant also won a competition in Robotics (engineering prize); The participant claimed to have felt proud of the projects in which had been involved (e.g. the digital watch project)
(2) Vicarious learning	The participant claimed that several opportunities to learn from professionals (wide range of academic role models) had been provided in the period during which the course happened (e.g. seminars, conferences, afterschool events and competitions). During such opportunities, such professionals/role models were contacted in order to gather information about the field and perceived as examples.
(3) Social persuasion	
(4) Physiological and affective states	The participant claimed to have felt nervous about trying to solve Robotics-related problems when pressured during the development of projects, classes or competitions

After each domain had been verified for a given participant, a new participant's list of factor and sub-factors influencing development of interest towards technology careers would be added. The list would, then, be filled with the information stemming from the codes identified for each factor, as it had been done for the previous participant. The process worked similarly for all participants including the attention to emergent factors and their recurrence. The recurrent factors were kept in the table containing individuals' information about the development of career interest. Upon completion of the coding and categorisation of data, Table 4.7 was developed in order to clarify the findings related to each participant.

Table 4.7: Findings related to the participants within the SCCT domains

Domain	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
SELF-EFFICACY	Personal Performance Accomplishments	Vicarious Learning	Social Persuasion	Physiological and affective states	None
Michelle	X			X	
Anne	X	X	X		
Ethelyna	X	X		X	
Luisa	X	X		X	
Andrea	X	X		X	
Amelia	X	X			
OUTCOME EXPECTATIONS	People's Appraisal	Observation of the outcomes	Attention to self-generated outcomes	Sensitivity to physical cues	Self-efficacy influence
Michelle	X		X		X
Anne	X			X	X
Ethelyna	X		X	X	X
Luisa	X		X		X
Andrea	X		X	X	X
Amelia	X		X		X

Data originated from different perspectives and sources informed the construction of tables such as Table 4.7 after saturation had been reached. When data could not confirm the development of a certain factor, it was considered that enough evidence had not been found to support the argument that a given participant had developed a certain aspect. The example presented in Table 4.7 indicates that only two sources of self-efficacy influenced Michele's and Amelia's perceptions on their development of self-efficacy because those were the arguments that could find support within the data-based findings.

4.8.4. Identification of the factors that could lead to the development of career interest towards technology in the case study level

The fourth step in the data analysis involved a within-case analysis of the process of developing career interest in each of the three case studies. Thus, outcomes for each participant were analysed and compared to the other fellow case study participants in order to theorise about their differences and/or similarities. Table 4.8 presents the within-case analysis developed for the Case Study 2.

Table 4.8: Within-case analysis regarding Case Study 2

Participants	Amelia	Andrea	Anne	Ethelyna	Luisa	Michelle
Self-efficacy	*Robotics *Electronics <u>*Programming</u>	*Electronics *Engineering skills <u>*Programming</u>	*Informatics *Electronics *Engineering skills *Robotics	*Informatics *Electronics *Engineering skills <u>*Programming</u>	*Informatics *Electronics *Robotics *Engineering skills <u>*Programming</u>	*Informatics *Robotics *Electronics *Programming <u>*Engineering skills</u>
Outcome expectations	*Teachers' / colleagues' appraisal; *Successful performance in classes, projects and competitions	*Teachers' / colleagues' appraisal; *Successful performance in classes, projects and competitions	*Teachers' / colleagues' appraisal; *Successful performance in classes, projects and competitions	*Teachers' / colleagues' appraisal; *Successful performance in classes, projects and competitions	*Teachers' / colleagues' appraisal; *Successful performance in classes, projects and competitions	*Teachers' / colleagues' appraisal; *Successful performance in classes, projects and competitions; *Success in the area of programming
Interests	<u>*No interest towards technology</u>	*Engineering *Programming	*Electronics: components; *Informatics: hardware	*Robotics Challenges	*Programming *Professional Skills	* HTML, Java, JavaScript, C++; * Autocad; * Computer Science
Goals	<u>*Applying for a vacancy within the Physical Education School</u>	<u>*Applying for a vacancy within the Physical Education School</u>	*Work in an electronics company; *Apply for an UG course related to technology	*Supervise a robotics challenge next year; *Become an advisor /volunteer at the CESMAR Centre	<u>*Applying for a public job unrelated to technology;</u> *Applying for a job related to electronics to pay for an UG Course (undefined field)	* Technology mentor /volunteer; * Supervise a robotics challenge; * Applying for a vacancy within the Computer Science School; * Work in a company related to the technology field

Participants	Amelia	Andrea	Anne	Ethelyna	Luisa	Michelle
Career consideration	* <u>Physical Educator</u>	* <u>Physical Educator</u>	* <u>Electronics Engineer;</u> * <u>Veterinary Physician</u>	* <u>Pedagogy;</u> * <u>Engineer</u>	* <u>Pedagogy;</u> * <u>Informatics Teacher / Technology Advisor</u>	* <u>Computer Science</u>
Broader view of labour market	*Limited contact with professionals from the technology field during the course	*Limited contact with professionals from the technology field during the course	*Broad contact with professionals within the technology field	*Broad contact with professionals within the technology field	*Broad contact with professionals within the technology field	*Broad contact with professionals within the technology field
Barriers	*Had to overcome personal learning issues	*Low salary paid through PJA	*Overcoming issues related to gender	*Lack of handouts related to programming; *Limited access to internet for solving issues related to programming	*Interaction with teachers; *Low salary paid through PJA; *Lack of technology equipment and access to information at home *Being her sister's legal guardian	*Lack of financial support; *Need to contribute to the family budget; *Suffers from anxiety
Supports	*CESMAR; *Financial / emotional support from family; *Has access to technology and information at home	*CESMAR; *Has access to technology and information at home; *Teachers' support (role models); *Emotional support from her partner	*CESMAR; *Teachers' support (role models); *Family provides financial and emotional support	*Family provides financial and emotional support	*CESMAR; *Teachers' support (role models); *Husband provides emotional support	*Family provides emotional support

For the within-case analysis process, each case study was viewed as a whole and differences and similarities between the development of interest towards technology careers for each individual case were identified and explained. The main goal in this stage was to identify the extent to which the participants could develop such interest and which factors, according to the SCCT, could explain that development or the lack of interest. The topics discussed for the within-analysis were the following:

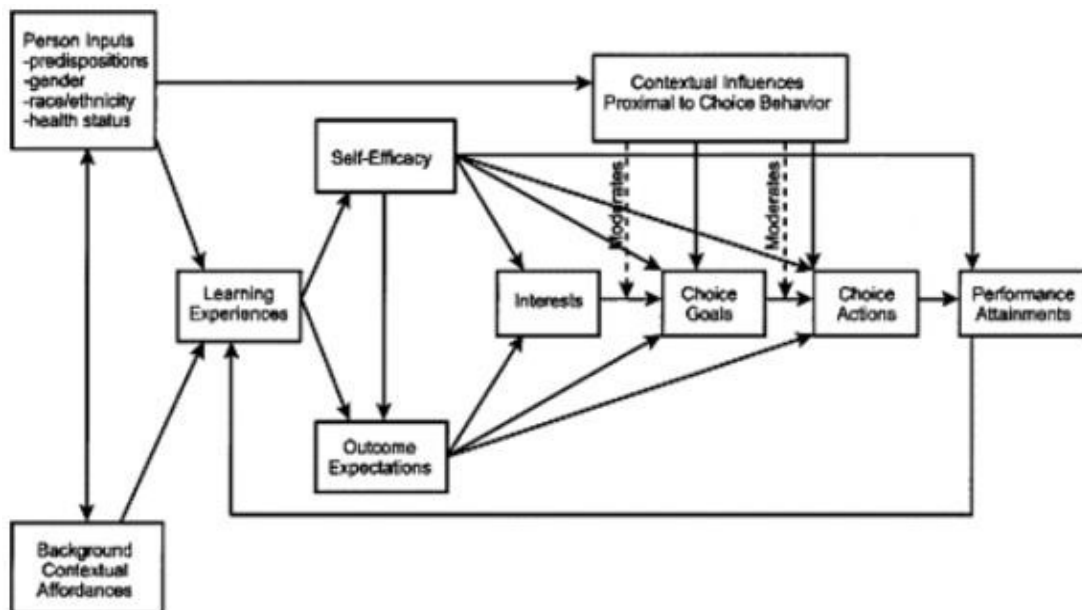
- (a) development of self-efficacy;
- (b) development of outcome expectations;
- (c) development of choice goals;
- (d) development of choice actions;
- (e) development of interest towards technology;
- (f) supporting factors on the development of career interest towards technology;
- (g) factors of barrier on the development of career interest towards technology;
- (h) development of a broader view of labour market;
- (i) analysis of development of career interest towards technology (pre-existing vs latest perceptions of career consideration);
- (j) development of confidence towards technology;

- (k) preferred ER approaches indicated individually and its relationship with the development of career interest.

4.8.5. The written form: from summarised findings to conclusions

The final step involved writing the conclusions regarding the outcomes of each SCCT domain, which enabled an understanding of the framework on the development of career interest towards technology within the case-study and individual levels. It was also possible to understand the extent to which career interest towards technology had been developed by each participant according to the data. Demographic factors such as age and gender were considered to respond the research questions. In order to understand the extent to which the participants could develop career interest towards technology, individuals' data were scrutinised under the SCCT model (see Figure 4.2).

Figure 4.2: Model of experimental factors affecting the development of career interest and behaviour (Lent et al., 2002, p. 269)



For example, data analysis indicated that 14 of the 16 participants developed interest towards technology. Such conclusion was informed by the SCCT model which proposes that interest, that is manifested through the development of choice and action goals, could be a product of the development of self-efficacy and outcome

expectations. Thus, a classification of the extent to which the participants developed an academic-related or career-related goals was proposed based on the same SCCT theoretical framework.

This section has presented the procedures through which data was analysed. The next section discusses the ethical issues that had to be considered during the development of this study.

4.9. Ethical Considerations

This study complied with BERA guidelines for educational research and the ethical guidelines presented by The Moray House of Education Ethics Committee concerning respect and responsibility with the participants (primary and secondary school students, their parents and teachers/mentors).

4.9.1. Clearance, privacy and disclosure

This study submitted ethics forms to the Moray House Ethics Committee on two occasions between 2014 and 2015. In October of 2014, this study was granted clearance for the first time, when the developed study protocol was tested, and data collected from whom would further become the Case Study 3 participants. Clearance was granted in November of the same year for the work to be developed within an educational setting which was not included in the final version of this thesis.

The second clearance was sought for this investigation in the second semester of 2015, so the fieldwork could be conducted *in situ*. At that time, it included the follow-up for Case Study 3 and the inclusion of face-to-face interviews within all the three case studies. Because the educational setting where the Case Study 3 participants is funded by the Porto Alegre City Council, clearance had also to be obtained from the Municipal Secretary of Education in June 2015. Clearance for developing an investigation project at the educational setting where the case studies 1 and 2 would be undertaken was obtained in July of 2015 through the approval of the Technology Centre Director.

Students, teachers and parents signed consent forms (Appendix 1), which presented an overview of the research and clarifications about all the steps regarding the access to the students and the educational settings. Participation was voluntary and unpaid.

Anonymity and the right to withdraw their participation at any moment was assured to the participants. Moreover, a clear explanation about the research objectives and timetable was provided in the forms and presented orally by teachers within each educational setting. Teachers voluntarily explained, before the fieldwork visits, how the two-stage investigation would be conducted.

According to Thomas (2013), the researcher should be particularly careful with ethical issues when there are minors involved in the research – especially if those minors present any learning difficulties and/or live in a violent environment, such as that where this study was undertaken. Both educational settings presented contexts which required strategies in order to deal with ethical considerations concerning potential risks that the contact between researcher and participants could represent. For the case studies 1 and 3, for example, the fact that the participants were adolescents had to be considered. Given that this study included Brazilian young learners from disadvantaged urban neighbourhoods from one of the most dangerous State capitals in the country, the following strategies were taken to minimise risks:

- (a) the researcher contacted the staff within the educational settings in order to be aware of any specific children policies about safeguarding that had to be applied to the specific group of students that had been sampled. Such information would help to adjust, if needed, the data gathering methods and approaches to the participants;
- (b) anonymisation of the participants' data;
- (c) reminding the participants of any stressful situations through which they had been gone and/or were going was avoided (especially regarding socioeconomic and/or contextual background influencing their career interest);
- (d) a model of the interview questions was sent to the faculty working in this study, in advance, to be reviewed and checked for any potential issues that those questions and/or topics could raise (e.g. psychological stress or discomfort). However, no changes were suggested by those who had received the questions for assessment;
- (e) rapport building with the students by having the teachers introducing the researcher, via Skype, before the beginning of the fieldwork.

During the fieldwork, the following procedures had to be followed if the interviewees revealed instances of abuse/neglect:

- (1) the students must be reminded by the researcher that what is told is confidential;
- (2) the researcher, depending on the case, can encourage the students to talk with someone who could help or, if it is the case, with the student's consent, the research can talk with someone (e.g. support group in Brazil related to children and young people protection) on the students' behalf;
- (3) in exceptional circumstances, such as the case of someone being put in a great risk, confidentiality may be broken without the participants' consent.

Fortunately, there was no need to apply any of those strategies because no participant revealed any instances of neglect or abuse.

4.9.2. Anonymity

All data collected for the development of this study was anonymised to preserve the identity of the participants (students, teachers, and tutors/mentors). Given that most of the participants in this study were minors, protecting them from any potential harm provoked by the disclosure of their identities was treated as a priority. Since this study was fully-funded by the Brazilian Government, the anonymisation of the educational settings did not occur, as it is a common practice that can be seen in similar studies which have been conducted nationally (e.g. Barbosa, 2011; Cabral, 2011; Campos, 2011; Lopes et al., 2008; Da Silva, 2009).

Ogden (2012) highlights that, for some participants, being recognised can be important or, even, the reason why one could have agreed to participate in a research study. That was certainly the case for some of the participants in this study; however, no exceptions were made regarding the anonymisation process. The previous anonymisation strategy had established that the participants would be identified by numbers, but, as suggested by the participants themselves, their birth names were replaced by pseudonyms. That new strategy aimed both to comply with the anonymisation procedures needed to conduct this investigation and to provide the participants with a certain degree of ownership towards their participation (Ogden, 2012). The participants suggested to be given common names within the English

Language (e.g. Daniel) or to be named after an English movie/book character (e.g. Albus). For the purposes of comparing the participants, some demographics, such as their age and gender, had to be revealed.

4.9.3. Translation

Since the researcher and participants' first language was Portuguese, concerns about the best strategies to address translation issues arose when the research plan was being developed – in the beginning of 2014. Marin and Marin (1991) propose that one of the main concerns regarding data translation is to produce a cultural equivalent to the instrument developed. For them:

[T]he translation process needs to go beyond finding the equivalent denotative meaning of the words used in the original version (literal translation) in order to capture the connotations or implied associations of the words. The identification of this connotative meaning is a process that surpasses finding the words' explicit (denotative) meaning in order to reflect properly their implied meaning as used by the researchers when drafting the instruments (Marin and Marin, 1991, p.82).

Oishi (2003) argues that the following aspects need to be achieved when translating:

- (a) semantic equivalence: which refers to the correspondence between the translated version and the original;
- (b) idiomatic equivalence: which refers to the fact that rarely idioms and colloquialisms are similar across two languages;
- (c) contextual equivalence: which refers to the need of developing questions which are understandable in the context of which the respondent lives; and
- (d) conceptual equivalence: which refers to the differences of meaning and content between translated and original items).

The strategy to address those issues (cultural, semantic, idiomatic, contextual and conceptual equivalency) involved the use of the services of a professional translator who reviewed, at least 20% of all the translated data from the transcriptions, data gathered in Portuguese. Thus, equivalences (in semantics, idioms, contexts, and concepts) were checked by the professional translator in the translated transcripts. The corrections which had been suggested by the translator were applied and trends (especially idiomatic and contextual) were reviewed in order to respect the

participants' perceptions and beliefs, enhancing, therefore, the quality in equivalency.

This chapter has provided the rationale for the methodology used to plan and conduct data gathering and analyse data for this investigation. A longitudinal multiple-case study informed the research design and the processes of data collection and analysis. This choice of qualitative approach has been justified. Homogeneous and purposive sampling have been presented as strategies for the recruitment of participants. Strategies to enhance research quality have been drawn. The methods of data collection and analysis have been discussed alongside the ethical considerations related to clearance, privacy, disclosure and anonymity.

CHAPTER 5 FINDINGS – PART I

5.1. Introduction

CESMAR is in the Mario Quintana District which is a low-income neighbourhood within the north sector of Porto Alegre. From its foundation, in 1886, until the first half of 1900s, that area was rural and scarcely populated. In the beginning of the 1980's, the region started to receive low-income families who had been relocated due to the processes of urbanisation and/or gentrification of the areas where they once lived (Troleis and Basso, 2011). According to the latest census (IBGE, 2010), 37.234 people live within the 2.7mi² area of the Mario Quintana district. The literacy rate in Mario Quintana, which is 94.7%, is similar to the state rate but higher than the national literacy rate, which is 91.7%. Average monthly family income is 1.68 minimum wage, which is very low, since other districts with similar demographics present an average between two and six times higher than that of the families from Mario Quintana. The region also presents high rates of violent crimes amongst youth and young adults (in 2012, 66% of the deaths in the area were crime-related and affected people between 15 and 29 years of age). In terms of infrastructure, 44% of the private houses were built in dangerous/unsafe areas and only 52.5% had electric energy. The table 5.1 highlights some demographic details about this study's participants.

Table 5.1 – Demographic details about case study 1 participants

Educational Settings	Students	Gender	Age	Level of Education
CESMAR Socio-educational Course	Albus	Male	14	8 th grade/Primary School
	Darwin	Male	15	9 th grade/Primary School
	Nathan	Male	16	8 th grade/Primary School
	Ulrich	Male	16	1 st year/Secondary School

Data was gathered for the investigation in this educational setting as described in the table below:

Table 5.2 – Data Collection Timeline

Activity	2015			2016											
	Oct	Nov	Dec	J	F	M	A	M	J	J	A	S	O	N	D
Monthly reports from teachers (from 01/10/2015 to 29/04/2016)															
Participant observations (from 26/10/2015 to 13/11/2015)															
Researcher's field notes (from 26/10/2015 to 13/11/2015)															
Monthly individual's interviews with participants (from 01/12/2015 to 29/04/2016)															
Monthly follow-up interviews with teachers and tutors (from 01/12/2015 to 29/04/2016)															
Focus group interviews during fieldwork (from 26/10/2015 to 13/11/2015)															
Analysis of documents from students (from 26/10/2015 to 29/04/2016)															

CESMAR is an institution that focuses on providing afterschool activities in the opposite school shift for the students within their community. Their main goal is to provide the community and their students with cultural workshops/courses, sporting activities, tutoring support and professional training. CESMAR is also a Secondary School and a Marist Centre of Technological Training. As a Marist Centre, CESMAR offers fourteen technological training activities, such as robotics for primary and secondary students, software development, computer repairing and PJA. For the purposes of this study, the following sections focus on the robotics course for primary and secondary students within CESMAR.

Both courses described in chapters 5 and 6 were developed according to rigorous parameters reserved for the implementation of technological courses for Primary and Secondary school students (Coelho, 2001; Senado, 2005). The curricula for those courses were aimed to provide students with plenty of opportunities to develop technology skills and enhance employability in this field, as further discussed. Similar to the previous ER setting (see chapter 5), the main pedagogical theories underpinning their curricula were constructivism, constructionism, and Vygotsky's social constructivism. In other words, both courses offered at CESMAR aimed to provide students with as many opportunities as possible to become the main agents of their learning process.

The difference between the courses at CESMAR and the ER setting at the Primary school seemed to be the main instructional strategies used in the first educational setting. The fact that the teachers at CESMAR would always be experts in the technology field without any background in pedagogical theory appear to have favoured methodologies in which peers were an agent in the learning process (Altin and Pedaste, 2013; Schunk, 2012). Teachers, however, would continue to be part of the process as facilitators and mediating the outcomes of individuals/groups. Peer-assisted learning and traditional instruction were the most performed strategies, according to the data gathered during this inquiry, while group collaborative learning was less frequently identified.

According to Schunk (2012), 'peer-assisted learning methods fit well with constructivism... (and) refer to instructional approaches in which peers serve as active agents in the learning process' (p.269). Its method includes peer tutoring, cooperative learning and reciprocal teaching. In peer tutoring, students are active in the learning process, where tutee and tutor can have a more inviting context to solve doubts that may occur in class. In cooperative learning, the main aim is to foster groupwork in a collaborative way, leading to a richer learning process if compared with traditional instruction. Finally, in reciprocal teaching, teacher and a small group of students are involved in a dialogical learning process, which could involve a previous question-strategy from the teacher(s) to determine to what extent students have understood the lesson. All ER approaches were identified as presenting peer-assisted learning methods used during their performances. For example, teachers in both courses would frequently develop activities structured to be conducted in pairs or small groups in which more advanced students could help those less advanced to perform the tasks supervised by their teachers.

Traditional instruction was the second most common instructional strategy identified by this study, which was not surprising, since the teachers at the CESMAR Centre, who were mostly experts in the technology field, had no previous background in Education. Another factor that explained the constant use of this instructional approach in which the teacher performs the main role in the learning process was the characteristic of their curricula, divided by learning modules and with limited time to be addressed.

Group collaborative learning, although not as frequent, was also identified as one of the instructional strategies used in both courses at CESMAR. For example, in ER classes, teachers divided the class into groups to investigate how a certain robotics sensor worked or the differences found in programming the robot in a certain way. The group, then, had to assign a task to each person, reach a conclusion about their findings, share with the group and organise the information. Finally, they had to present the information to the other groups and discuss their findings.

This section reports the findings of the Case Study 1 which focused on the development of career interest towards technology according to the SCCT framework found in Lent et al. (2002). Firstly, perceptions on the relationship between the preferred ER approach and the development of self-efficacy are presented. Second, the development of self-efficacy and outcome expectations beliefs, as well as the participants' interest during their involvement with ER approaches, within the context of the Case Study 1 are addressed. Then, the development of choice goals, as a result of development of interests, self-efficacy and outcome expectations beliefs, are analysed alongside external factors (supporting and barriers) which might influence such development. Additionally, changes in the participants' perceptions on career interest and attitudes stemming from their participation in ER approaches are discussed. Finally, initial conclusions concerning the findings regarding the Case Study 1 are drawn.

5.2. Case Study 1: Socio-Educational Course / CESMAR Centre

The socio-educational course was created in partnership with the Foundation for Social Assistance and Citizenship (FASC – Fundação de Assistência Social e Cidadania), a managing body within the Porto Alegre City Council which is responsible for providing services and programmes that promote social inclusion. The course offers socio-educational activities for socially at-risk young people (between 14 and 18 years of age). Students are provided with four-hours after school activities three times a week (12 hours a week), which include activities encompassed in the course curriculum as well as Physical Education, fieldtrips and snack time.

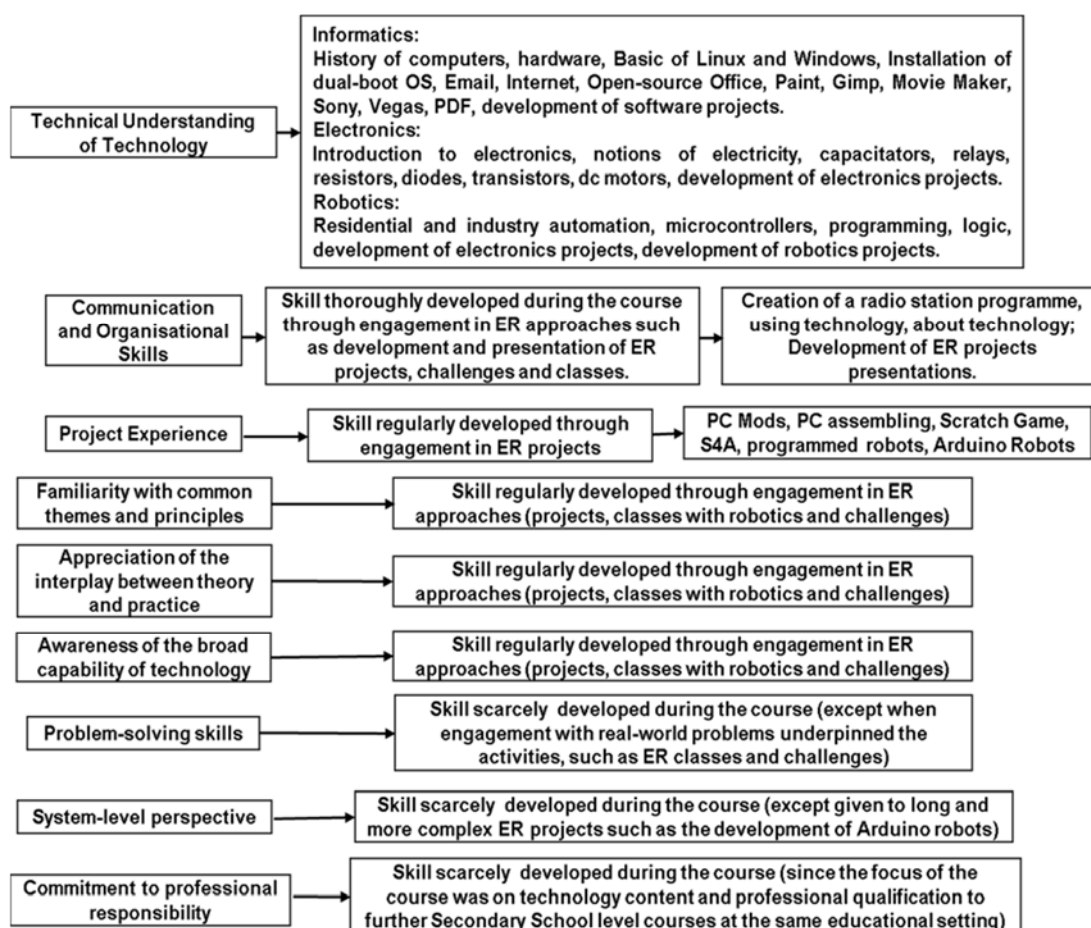
The course is organised around two main subjects – Informatics and open-source robotics – and 32 topics (such as history of informatics, hardware, software, programming logic, electronics, robotics, etc.). The students are assessed monthly according to their understanding of the three ER approaches that are developed during the course: ER classes, ER projects and ER challenges. This 12-months course is usually the first stage through which the students go in order to apply for a placement in other courses within CESMAR which require a previous knowledge regarding informatics. The students who conclude the social-educational course and are interested in continuing their studies at CESMAR can be the first applicants to apply for other courses with scholarships that are provided by programmes such as PJA. It is important to highlight that, for the most part, the socio-educational course is more focused on the Informatics' core of topics than ER. That means that during this study, the learning on case study 1 was not actually based on ER, as it was for cases 2 and 3. Therefore, one must have in mind that the results for this case may be more about the benefits of taking the whole course than the impact of ER. Accounts from participants throughout this chapter indicate when another source which not ER are main influence on the development of career interest or technology skills.

The socio-educational class at the CESMAR Centre aims to guide students towards courses within which scholarships are offered through the Young Apprentice Federal project. ER was chosen to be the main subject of the course since it involves hands-on activities and is a learning tool which relate to other areas (such as Informatics and Electronics). The next sections explore a within-case analysis that focuses on the development of career interest in technology according to the SCCT model which was previously explained (see Chapter 4). Findings regarding (1) self-efficacy; (2) outcome expectations; (3) development of interests; (4) choice goals and actions; (5) supporting and barrier factors; and (6) development of career consideration and confidence are further discussed in relation to the SCCT model for basic development of career interest towards technology.

5.3. Analysis of the development of technology skills in case study 1 participants

The reviewed literature about vocational psychology indicated that self-efficacy and/or outcome expectations could play an important role in the development of career interest. For this reason, this chapter begins with the analysis of the technology skills developed in each case study through the curriculum or the ER approaches developed. For example, if students were able to develop technology skills, one could hypothesise that they would have more chances to develop self-efficacy and, therefore, career interest towards technology (for the framework used to develop this analysis, see Chapter 4). Figure 5.1 details the skills developed by the Case Study 1 participants.

Figure 5.1: Technology skills developed by the Case Study 1 participants



Case study 1 curriculum was developed in order to give students the opportunity to learn about digital literacy, electronics and robotics to the point that they would, in the end of the course, be able to apply for more complex courses at the same Technology

Centre [CESMAR - Interview with the Course Pedagogical Coordinator/2015]. In terms of technical understanding of technology, the Case Study 1 participants had the opportunity to learn more contents related to digital literacy than Electronics or Robotics. That seemed to be because of the characteristics of the course itself, which aimed to provide the students with basic knowledge about Informatics, Electronics and Robotics so that they could attend the other courses that were offered at the CESMAR Centre.

Despite having been developed to include robotics kits as the main hands-on educational tool, students started working exclusively with robotics after they had been attending the ER classes for six months. During the first six months, students built their own computers and had initial contact with robotics kits (e.g. Arduino and one of sit graphic languages, S4A). There had been many opportunities to develop communication and organisational skills through the participation in ER projects – such as the project involving the radio station shows. The experience with projects and the advancement of teamwork had been facilitated by the development of games, robotics and informatics projects. Familiarity with common themes and principles, awareness of the broad applicability of technology and problem-solving – which are skills related to critical thinking – were regularly developed during the course.

Skills involving system-level perspective and commitment to professional responsibility were found to have been developed scarcely throughout the course. It can be argued that the course did not focus on the advancement of those particular skills; rather, it aimed to encourage the students to develop those skills by attending other courses at the Centre. Finally, an aspect addressed in case study curriculum is that several skills were worked through more than one ER approach. For example, technical understanding of technology was worked throughout all three ER approaches, and even ER classes encompassed opportunities to practice problem-solving and project experiences.

The next section addresses the development of career interest towards technology in case study 1 participants.

5.4. Analysis of development of interest towards technology careers in case study 1 participants

According to Lent et al. (2002), learning opportunities as the ones this study's participants took could lead one to develop an interest towards a determined type of career. In this investigation, the SCCT model of development of career interest (Lent and Worthington, 1999; Lent and Brown, 1996) is the theoretical framework used to analyse to what extent the development of interest towards technology careers occurred or not in each participant of the cases here investigated. In the next sub-chapters, all the factors that are part of the SCCT model are examined. In the final sub-chapter, an answer about the extent to which participants developed an interest towards technology careers after taking part of ER approaches in their educational settings is provided.

5.4.1. The development of self-efficacy

Self-efficacy is, alongside outcome expectations and choice goals, one of the most important constructs of the SCCT theory (Brown, 2002). According to Lent et al. (1994), self-efficacy beliefs can help to determine one's choices of activities and environments through sources – such as personal performance accomplishments; vicarious learning; social persuasion; and physiological and affective states – when one is confronted by obstacles (Brown, 2002). In order to understand the extent to which career interest in technology was developed within that context, the students were interviewed regarding their self-efficacy beliefs. Self-efficacy beliefs might change over time; however, examining the areas claimed to be the students' academic strengths is important since prospective positive self-efficacy beliefs towards technology can result in the development of interest in it. Table 5.3. presents the self-efficacy sources according to the participants.

Table 5.3: Sources of self-efficacy according to the Case Study 1 participants

Self-efficacy	Personal Performance Accomplishments	Vicarious Learning	Social Persuasion	Physiological and affective states
Albus	Hardware Assembling Programming (Minecraft) Arduino Scratch (neutral) Windows (neutral)	Teachers	-	Happy and anxious (Arduino)
Darwin	Informatics Programming (Scratch) Software installation	Teachers (specially) and colleagues	-	Focused
Nathan	Informatics Programming Robotics	Teachers	-	-
Ulrich	Programming (S4A) Arduino Engineering Electronics in general Electronics with Arduino	Teachers	Teachers	Learning difficulties and anxiety while dealing with robotics activities.

All four participants were able to state positive self-efficacy beliefs towards personal performance accomplishments at some point of the course. Observations and interviews with students and teachers evidenced that the students developed positive self-efficacy beliefs towards the activities. CESMAR Centre was developed to be an environment for vicarious learning; however, for the students, the main source of self-efficacy was their accomplishments. Such findings are supported by the following responses provided by the students when asked about which activities made them feel prouder of themselves during the course:

I was so proud of myself! I was already doing an adult's job, which only people who were advanced in the courses would do (...) I had to do it neatly and correctly.

Albus

Because it was my first time doing that and I was able to finish it. The teacher said: "Don't give up. You can do it. Think." (...) I did it and finished it.

Ulrich

The first time I fixed a computer I was very proud of myself. Because I didn't know how to fix it (...) I asked the teacher how to do it and he taught me. Now, I've been progressing, but, the first time I did it...Wow!

Darwin

The Socio-Educational Class curriculum was developed to introduce common topics to all technological courses that are available within the CESMAR Centre – such as Informatics (e.g. Hardware, Software, computer reconditioning and fixing), Electronics (e.g. protoboard, electronics components) and open-source robotics

(Scratch, S4A and Arduino). All four participants stated positive self-efficacy beliefs towards the activities involving Informatics and Electronics. Ulrich presented negative self-efficacy beliefs towards his performance with open-source robotics' activities whereas Albus, Darwin and Nathan presented positive self-efficacy perceptions. An example of that is Nathan's response, below, to the question about the activities that made him prouder of himself:

When I was able to fix computers and I was able to build a robotics project with Scratch and S4A.

Nathan

Vicarious Learning is the second source of self-efficacy indicated by the SCCT theory (Brown, 2002). Considering the mission of CESMAR Centre in facilitating vicarious learning, professionals, educators and occasional speakers from the technology field have been helping with the courses (Interview, CESMAR Centre, CESMAR' s Pedagogical Coordinator). Interview data indicated the importance of vicarious learning. All four participants claimed that their primary source of positive self-efficacy beliefs through vicarious learning were their teacher/s. Alongside his teachers, Darwin attributed to his colleagues the role as a source of vicarious learning. The following extract presents Albus' response to the question about the extent to which their teachers and/or colleagues contributed to his learning and/or performances:

Teacher Nelson was installing in a computer in the beginning of the course. We were kind of learning how to assemble and disassembling it and I observed him doing everything very fast like it was super easy. Things that would probably take me hours to do (...) I asked him how I could do the same and he taught me step by step, slot per slot, RAM memory...

Albus

Social persuasion is another source of self-efficacy. Although social persuasion might work momentarily as source of self-efficacy, it is a strong source of depreciation of self-efficacy for individuals who had been convinced to be capable of doing something when they cannot (Brown, 2002). Interview data evidenced that social persuasion was not a major source of positive self-efficacy beliefs between those students. Since that course was a requirement for more complex courses within the CESMAR Centre, activities which could lead to social performance (e.g. robotics

competitions or projects) were perceived to be a positive outcome by those involved. Because the focus of the course was the use of robotics as a learning tool, the variety of topics and the everchanging members of the group might have minimised the possibility for social persuasion.

Psychological and affective states was also identified by those students as a source of positive self-efficacy beliefs towards the technology activities being developed during the course. According to the SCCT, one's emotional and somatic states can be considered in order to evaluate one's abilities to perform a certain activity (Brown, 2002). Interview and observation data indicated that all four participants' performances were influenced by this source of self-efficacy. The students claimed to have felt initially nervous and eventually focused on the tasks. When asked about how he felt when trying to solve an ER problem, Darwin responded as follows:

I think "ok, enough of playing around now and pay attention on that". I keep focused on that, try to do it, ask the teacher for help, the teacher explains something to me, then I do it.

Darwin

The next section focuses on outcome expectations within the context where Case Study 1 was undertaken.

5.4.2. Within-case analysis of outcome expectations for the Socio-Educational class

According to Lent et al. (1994), outcome expectations involve the anticipated consequences of one's capabilities of accomplishing a specified goal (or, If I can do this, what will happen is...). Learning experiences, such as those reporting self-efficacy, are the sources to obtain outcome expectations. According to Brown (2002), the five sources of outcome expectations, which are discussed in this study, are the following:

- (1) people's appraisal (e.g. awards) for the outcomes resulting from the development of specific actions;
- (2) observation of the outcomes produced by other people;
- (3) consideration of self-generated outcomes and the reactions of others;

- (4) sensitivity to physical cues (e.g. level of emotional excitement, sense of happiness) during performance; and
- (5) influence of self-efficacy when outcomes are determined by the quality of one's performance.

In this sense, in order to understand the extent to which the career interest in technology increased in the participants of Case Study 1, outcome expectations were gathered through interviews and observations. Table 5.4. presents the students' perspectives regarding the sources of outcome expectations.

Table 5.4: Sources of outcome expectations according to the Case Study 1 participants

Outcome Expectations	People's Appraisals	Observation of the Outcomes	Attention to self-generated outcomes	Sensitivity during Task Performance	Self-efficacy Influence
Albus	X	X	X	X	-
Darwin	X	-	-	X	X
Nathan	-	-	-	X	X
Ulrich	X	-	-	-	X

Outcome expectations, as self-efficacy, can derive from the learning experiences promoted within the course. While responding to questions about what influenced their outcome expectations towards a career interest in technology, most of the students emphasised people's appraisal, sensitivity during task performance and self-efficacy influence as the main sources of outcome expectations. Observation of the outcomes and attention to self-generated outcomes were mentioned by one of the three participants.

People's appraisal, which was identified as source of outcome expectations by Albus, Darwin and Ulrich, stems generally from colleagues', teachers' and/or relatives' comments addressed to the participants in order to reassure them and/or to acknowledge the success of their performance. The extract below presents Darwin's accounts of his family support:

They talk...supporting me (...) not only talking to me but helping me with things. They're like "ok, now you do this, write a question there, solve this thing here, solve that other thing there". Many times, I ask my uncle: "how do I do this or that"? (...) He knows some things.

Darwin

Influence of self-efficacy beliefs towards technology was also identified by the students, except for Albus, as the main source of outcome expectations. When asked about which activities they could redo or which learning experiences they felt more comfortable repeating, the students mentioned the influence of self-efficacy beliefs. For example, Nathan responded, 'Build a project with the S4A' – which is the activity he had identified to be the one that made him prouder of himself.

Sensitivity to physical cues during task performance (e.g. sense happiness, emotional arousal) were mentioned by Albus and Darwin as sources of outcome expectations. Despite not being considered the most important source, theorists relate the identification of well-being during a task performance with the development of interest towards the same action (Athanasou and Van Esbroeck, 2008; Brown, 2002; Holland and Nichols, 1964; Lent et al., 2008; Vondracek et al., 2014). This argument seems to be supported by the following account:

How did I make that happen? Wow, a led, right? It seems so difficult to make the whole thing and it is only a matter of transferring everything to the computer, make it take all the steps (...) and that's how I started to learn (...) I felt anxious when I made the led turn on and off.

Albus

Albus was the only participant who identified observation of the outcomes and attention to self-generated outcomes as sources of outcome expectations. Albus' history and connection with the Centre, combined with the fact that he had planned to participate in that course, might have contributed to his positive attitude towards every aspect of the learning experiences. In the next extract, Albus explains why he felt proud of his performance in an Informatics project (during which he reconditioned a machine to be his own for the duration of the course) because such activity and topic was developed by older students:

It seemed that I was there and already knew (...) they were learning about things that I already knew and that was very cool (...) I dream about working at some point, for Rockstar, Microsoft or Google.

Albus

Outcome expectations can also stem from self-efficacy when they are 'determined by the quality of one's performance' (Brown, 2002, p.263). Darwin, Nathan and Ulrich

identified this type of outcome expectation beliefs, which are intertwined with their self-efficacy beliefs. Their outcome expectation beliefs about the quality of their performances were related to Informatics (Darwin), Robotics/S4A (Nathan) and Electronics/Informatics/Robotics (Ulrich). An example of such assumption can be found in Darwin's response, below, to the question regarding the activities that he felt to be more prepared to repeat successfully:

Fixing the PCs because if I do something wrong, after that, I know I can do better. I keep doing, learning and doing everything better. The PC activity showed me that the more I learn the more I feel that I can do better (...) defective PC parts, like, motherboards, must be taken off, replaced by an identical one and put right back on the same place. After doing that, you test it, and re-test it and, when the computer starts to turn on correctly, it's done.

Darwin

Darwin's response represented more than his outcome expectation beliefs towards informatics, it revealed that Darwin had achieved a meaningful degree of confidence towards Informatics – especially hardware. Not only did Darwin seem to know the process of “fixing the PC” (detecting the issue, testing solutions, re-testing, evaluating), but he also had understood that practice meant better learning (“the more I learn...”).

5.4.3. Within-case analysis of the development of interest toward technology

An important aspect of the development of career interest towards technology is when such interest is a result of the participation in meaningful learning experiences within the Socio-Educational Course and is related to the students' self-efficacy and outcome expectations. Table 5.5. summarises the development of the identified students' interest towards one of the technological topics comprising the course curriculum.

Table 5.5: Case Study 1 participants' interest towards technological topics

Topic of interest	Software development / programming	Informatics	Electronics
Albus	X	-	-
Darwin	X	X	-
Nathan	X	-	-
Ulrich	-	X	-

None of the students presented interest towards Electronics; however, despite not being part of the Informatics curriculum for that course, Software development was identified as a topic of interest by three of the four students. Given that the Technology Centre offers a Software Development Course, the students' interest towards it can be interpreted as the development of future goals (e.g. desire to participate in that course in the future). The following extract presents Nathan's explanation about his interest towards software development.

I got very interested in learning about software programming (...) I started to think about attending a course about it here [CESMAR Centre]. I want to know more about software because I am more interested in mobile phones. I learned about them and how they are built, the apps and everything.

Nathan

Nathan's initial interest in mobile phones (a topic addressed in the Course curriculum) seems to have led him to start investigating them. Nathan learned that there was another course addressing this topic within the Centre and that he could eventually attend that course. The fact that the educational context in which Nathan participated provided feedback for his interest seemed to have helped to develop his interest towards software development. Albus also claimed that he became interested in programming as follows:

I thought about doing that [research about software], but, when I started researching about it, our teacher installed a software called Scratch, which can make you move a cat and I almost created a game with that. Two colleagues of mine developed a game (...) I've started developing a game too, but I couldn't finish it (...) I made the pictures move and had the idea of how it's going to work (...) it might happen when I start attending my next course.

Albus

Although Albus did not have the same knowledge about software development as Nathan, he claimed to have enjoyed the experience with S4A and Scratch software – which happened concomitantly to the development of his interest towards it. Albus also expressed his desire of attending the Software Development Course at the Technology Centre to improve his programming skills. The findings evidenced that all the participants had developed, to a certain extent, interest towards technology topics – especially Informatics, Robotics, Programming and Software development. The interest in the latter appears to be related to Albus', Darwin's and Nathan's previous interest in games and practices within the course. Moreover, the existence of a course at the Technology Centre and the contact with teachers and other students might have influenced the development of interest. The Centre can be considered crucial for students such as Albus, Darwin and Ulrich who did not have a computer at home and could rely only on the access to information and peer interaction at the Centre to nurture that interest.

Darwin and Ulrich expressed an interest towards Informatics. For Ulrich, his performance in the course started improving after a teacher had shown the group that the computers at the Technology Centre could be used for more than playing. Ulrich stated the following:

I used to be interested in games only, I used to play a lot. Then, a teacher at the Informatics course asked: 'Do you think that Informatics is just playing around?' (...) And then I decided to be more interested in things other than playing games.

Ulrich

Ulrich's realisation was important, since it seemed to have helped him to take the course more seriously. Other contextual factors (such as family pressure and the plan to develop his own business) might have helped him to take advantage of his time at the Centre (further details in Section 5.2.1.5). For Darwin, as presented in the following extract, the development of interest was expressed when he talked about his plans for a PC:

I'm getting a PC (...) I'm going to improve it (...) my goal is to apply everything I learned here, to use Scratch, the S4A.

Darwin

Darwin also identified several barriers for his vocational interest towards technology – amongst which the lack of a computer at home must be emphasised (further details in Section 5.2.5). However, his enthusiasm in applying what he had learned and installing that specific software can be interpreted as an interest towards the topics he had been taught at the Centre.

This section has focused on the development of interest towards technology stemming from learning experiences within the Socio-Educational Course according to the participants. Findings revealed that all the participants developed, to a certain extent, an interest related to technology (e.g. software development or programming and Informatics). The next section presents the findings regarding the development of choice goals and actions in order to clarify whether the goals established by the participants were related to their interest, positive self-efficacy and outcome expectation beliefs.

5.4.4. Within-case analysis of choice goals and actions towards technology

Choice goals and actions are described in the SCCT model as intentions or purposes to engage in a certain activity or develop a specific outcome (Lent et al., 1994). Table 5.6 summarises the types of goals identified by the participants after attending the Socio-Educational Course for at least 6 months. Albus, Darwin and Nathan identified attending another technological course soon as a goal. Albus and Nathan identified enrolling in an undergraduate course in technology (respectively, Software Development and Computer Science) as a goal in their lives. Albus, Darwin and Ulrich identified becoming entrepreneurs and/or opening their own business soon as a goal.

Table 5.6: Case Study 1 participants' Choice Goals

Choice Goals	Academic / Technician	Academic / Undergraduate	Career-related	Entrepreneurship
Albus	X	X	-	X
Darwin	X	-	-	X
Nathan	X	X	-	-
Ulrich	-	-	-	X

5.4.4.1. Choice goals

In order to understand whether there was development of choice goals towards technology, four outcomes were established as possible for the participants: (1) to attend a technology course; (2) to go to college (undergraduate course); (3) an apprenticeship opportunity; and (4) entrepreneurship. Different goals were identified by the students – mostly according to the impact of supports and barriers (see Section 5.2.5). For Brown (2002), supports and barriers influence the process of development of career interest by accommodating one's goals, actions and interest to factors such as availability, skill, opportunities and social structure.

Albus, Darwin and Nathan intended to apply for academic opportunities towards technology, initially, at CESMAR. For them, the availability and the opportunity to be granted a scholarship by PJA seemed to have played a role in the development of choice goals towards technology, as the following extract suggests:

After finishing this course, I'm going to participate in the Young Apprentice project, because, after that, I'll start a career.

Albus

Entrepreneurship was identified, by Albus, Darwin and Ulrich, as choice goals towards technology as explained in the following extract:

I could open a small company, a micro company, for myself. I'd like to help the community, do something like CESMAR did here for this community (...) something focused on software.

Ulrich

For Ulrich, entrepreneurship as the only identified goal since, as it is further discussed in Section 5.2.1.5, socio-structural barriers and the lack of financial support have influenced him to start working rather than pursuing academic studies. No participant identified career-related goals, which can be explained by their young age (14-16 years of age) and the possibility of being granted a scholarship to study in a technological course after attending the Socio-Educational Class for a year. Nathan and Albus identified college (technology-related undergraduate course) as a choice goal. Such choices might be a consequence of their positive self-efficacy beliefs and outcome expectations towards Informatics, Electronics and Robotics, as well as their

expectations regarding their performance in learning experiences with technology. Nathan's explanation below supports this argument.

I think Informatics is cool and interesting. I've been thinking about going ahead and start an undergraduate course in Computers Science.

Nathan

Nathan's sense of well-being and positive self-efficacy beliefs towards Informatics seemed to have been drawing him to an academic-related prospect. Furthermore, as previously mentioned, Nathan could rely on his relatives' and the school staff's support to pursue opportunities within such field. Albus, whose academic interest towards technology also involved attending an undergraduate course, claimed to have been interested in developing a game before starting the course at the Centre. The availability of technical courses and higher education courses related to software development, which was identified as a goal by him, might have influenced the development of his career interest.

5.4.4.2. Choice actions

Choice actions concern one's effort to implement choice goals; moreover, they can be moderated by supports and barriers and influenced by self-efficacy beliefs and outcome expectations (Brown, 2002). Interview and observation data revealed one choice action: participating in other technology-related courses at the Centre. Since the Socio-Educational Class is a preparatory course for those who might get scholarships within the Centre, continuing their studies at the Centre was a choice action towards a career interest in technology.

Nathan, who had been attending the Socio-Educational Class for over a year, was invited to attend the Computer Reconditioning Course (CRC) within PJA when data was being gathered for Case Study 1. That might have been the reason why Nathan, as suggested by the extract below, expressed a career interest in technology.

I was invited by the coordinators to start the CRC (...) to start repairing computers and to have a deeper understanding about them (...) to develop my knowledge about computers (...) to learn a little bit more than what I've already learned so far in this course.

Nathan

The other three participants of Case Study 1 did not identify any choice action, which can be explained by the fact that they had been attending the course for a relatively short period of time. Teachers and staff explained that the course received new students every month whereas those who completed one year could be invited to attend more advanced courses available through PJA according to their progress within the Socio-Educational Course [Interview with teachers and staff, CESMAR Centre's Socio-Educational Class]. The next section focuses on external factors, supports and barriers, which might influence the development of career interest towards technology.

5.4.5. Within-case analysis of supports and barriers

Supports and barriers are factors that could potentially influence the development of career interest towards technology of the participants of Case Study 1. The following sections discuss the findings regarding the factors which were identified through data originated from interviews, observations and field notes.

5.4.5.1. Supporting factors on the development of career interest towards technology

Table 5.5 presents the supporting factors identified by the participants, two of which can be found in the SCCT model (Brown, 2002; Lent et al., 1994): (1) opportunities for skill (availability of learning opportunities in which skills can be learned); and (2) emotional and financial support. The other two supporting factors within the SCCT model – (3) range of potential academic career role models (availability of direct contact with professional models); and (4) cultural and gender role (positive examples stemming from culture or gender) – were not identified by the participants. However, the interviews with teachers and staff revealed the importance of introducing role models for the students attending the course [Interview with Teachers, CESMAR, Socio-Educational Class].

Table 5.7: Supporting factors identified by the Case Study 1 participants

Supports	Opportunities for Skill	Proximal Influences (Emotional / Financial Support)
Albus	X	X
Darwin	X	X
Nathan	X	X
Ulrich	X	-

Nathan, Albus, and Darwin claimed to have received more support than Ulrich; however, the supporting factor related to opportunities for skill was identified by all the participants. Opportunities for skill development represent a set of activities which were available within the Socio-Educational Course or because of it. Darwin's statement, below, exemplifies the opportunities for skill that are offered at the Centre.

I was looking for a robotics course and I wanted to start attending it as soon as possible (...) when I started here [at the Centre], I wanted to attend this course, not others (...) looking back now, since I'm almost getting paid to start a robotics course, I think I saved money, right?

Darwin

Darwin's account confirms the fact that courses such as those offered at the CESMAR Centre would not be free of charges elsewhere, which indicates the importance of the opportunities for skill development within the Centre. Nathan, who had just been offered a spot to attend the CRC, is an example of the supporting factor related to opportunities for skill development within the Centre. Field notes revealed that Nathan after having received the news, was joyful, surprised and proud of himself [Researcher's field notes, CESMAR Centre's Socio-Educational Class]. As part of the process, Nathan's suitability to move forward and participate in the CRC had to be assessed by his teachers and the Centre staff. In this sense, the Socio-Educational Class was supposed to provide Nathan with opportunities for the development of skills which enabled him to achieve a certain degree of professionalism and knowledge about Informatics.

Ulrich listed, as opportunities for skills development, 'learning how to use Word, PowerPoint, Windows, fixing computer pieces and Scratch' [Interview, CESMAR Centre's Socio-Educational Class]. Ulrich's account confirms the course curriculum

which covers, amongst other topics, basic computing and Informatics (Microsoft Office, Operational Systems, programming) focusing on robotics (Scratch, S4A, Arduino). The participants did not identify any negative aspects related to the opportunities for skill. Although some participants mentioned several factors of barriers (see next section for further details), the opportunities for skills development seemed to have been the most important supporting factor for them.

Considering that supporting factors might influence the development of career interest towards technology, the course syllabus (Appendix II) which focuses on topics such as History of Informatics and Free Projects on Robotics, seemed to provide the students with many opportunities to develop technology skills. Technical knowledge and an overall understanding about common themes and principles related to Informatics and Robotics were emphasised possibly due to students' age (12-16 years of age) and their level of instruction (Primary School).

The second supporting factor which is part of the SCCT model and mentioned by most of the students and, therefore, analysed in this study is the proximal influences (Lent et al., 1994; Patton and McMahon, 2006). Proximal influence (or emotional and/or financial support) was a meaningful supporting factor for the participants in Case Study 1 in terms of the development of their interest towards technology careers. According to Lent et al. (1994), such influence is not surprising, since the lack of support from significant people can be discouraging even if one's self-efficacy/outcome expectations are positive.

Albus, Darwin and Nathan claimed to have had plenty of support whereas Ulrich did not identify family support. Albus' example of support is related to the fact that 'some people study at CERMAR since kindergarten' [Interview, CESMAR Centre's Socio-Educational Class]. Albus identified as an important proximal influence the fact that he knew some of his colleagues since they started studying at the Centre (when they were 5-6 years old). Darwin shared a similar opinion about the colleagues with whom he had studied for a long time. Albus also emphasised his family support as follows:

My two sisters have already taken this course (...) So I can ask them 'Hey, sis, have you learned about Scratch?' (...) 'can you tell me a little bit more about that?' And they teach me how to code and things like that.

Albus

Having two sisters who had already participated in the Socio-Educational Course seemed to have influenced Albus and was identified by him as a supporting factor. Albus' perception can find support in Lent et al. (1994) who argue the following:

Interest-goal and goal-action relations will tend to be stronger amongst persons who perceive beneficial environmental conditions (e.g., presence of ample support, few barriers) and weaker among those who perceive less favourable conditions" (p. 107).

Albus appeared to have had meaningful support from both family and peers. For Darwin, as the following extract suggests, family support was also a meaningful supporting factor, even though his family did not share his interest in technology.

My father and my mother are the ones who support me the most (...) They keep saying things like 'go and do your best, at least you'll know more, you'll evolve more (...) you'll know what to do' (...) and they're right because learning new things is so good (...) I'm very curious but I can't ask my father, he's not a computer specialist (...) my father keeps saying 'don't skip class, it'll help you in your future'

Darwin

Darwin's family support seemed to have encouraged him to attend the Socio-Educational Course and might influence his decision to continue studying at the Centre. Nathan was the participant whose supporting factor related to proximal influence was outstanding. Alongside his family, Nathan could rely on the support from the school staff, teachers and headmaster who developed an educational programme for students, like himself, who had not achieved the minimum level of instruction (completion of Primary School). Nathan summarised his family support by claiming that his parents would not allow him to stay home and skip school without a reason [Interview, CESMAR Centre's Socio-Educational Class]. Such support might have helped Nathan to be granted a scholarship to attend the CRC after having completed the Socio-Educational Course.

Ulrich was the only participant who did not identify proximal support as a supporting factor for the development of his career interest in technology. According to Ulrich, his grandmother, who had been his sole legal guardian, did not support his decision of attending the course. Because Ulrich was 15 years old when he started attending the course, his grandmother would rather have Ulrich working to increase the family

income, (see the next section for further details). Ulrich explained such situation as follows:

she [grandmother] says that she wants the best for me (...) if it weren't for me I wouldn't be here, I'd be working somewhere (...) I asked her: 'grandma, can I go there?' I told her 'I'll be able to start my own company, to work, these kinds of things'.

Ulrich

Ulrich's attendance seemed to be related to (a) his successful achievements within the course; and (b) the chance to be granted a scholarship or the opportunity to use what he had learned to start his own technology-related business. Despite being the participant who received less support from his family, Ulrich showed enthusiasm and self-motivation.

5.4.5.2. Factors of barriers on the development of career interest towards technology

Three of five factors of barrier addressed by the SCCT model were identified by the Case Study 1 participants: (1) cultural role; (2) socio-structural barriers; and (3) health status or predispositions (Brown, 2002). Table 5.8 presents the factors of barriers which were identified by the participants.

Table 5.8: Factors of barriers identified by the Case Study 1 participants

Barriers	Cultural	Socio-economic	Health status or predispositions
Albus	X	-	-
Darwin	X	X	-
Nathan	X	-	X
Ulrich	X	X	X

Although socio-economic barriers and health status or predispositions were mentioned by two participants, the findings revealed that socio-structural barriers are the most meaningful factor influencing the development of Case Study 1 participants' career interest towards technology. According to the Centre's Director, all the courses which were offered at the Centre, such as the Socio-Educational Class, had been planned to simulate a professional environment. In so doing, the teachers were also supervisors and the Centre staff supported both teachers and students to achieve the desired outcomes within this simulated environment. The students

attending the Socio-Educational Class were assessed in terms of their knowledge about Informatics and Robotics and their professionalism.

The students identified the assessment of their professionalism as a barrier because of their struggle to overcome the embedded culture of violence within their local community. The students' accounts can find support in Miller and Miller (2008) who argue as follows:

School violence includes but is not limited to such behaviours as child and teacher victimization, child and/or teacher perpetration, physical and psychological exploitation, cyber victimization, cyber threats and bullying, fights, bullying, classroom disorder, physical and psychological injury to teacher and student, cult-related behaviour and activities, sexual and other boundary violations, and use of weapons in the school environment (p. 15).

In the period during which data gathering was taking place, several accounts regarding violence were shared by those who attended classes and/or worked at the Centre. Although school violence is not discussed in this study, its influence, as a barrier factor, on the development of the participants' interest towards technology is analysed. The next extract presents Nathan's explanation of how such barrier factor occurred.

Sometimes, someone decides to pick a fight with me, scolds me, I scold back and, then, I ask the teacher for me to take a break (...) I do what I can to avoid getting involved in fights

Nathan

Supporting the interview data, observation data revealed the following:

- (1) new students struggled to perceive the Socio-Educational Class as an educational environment and tended to confront their colleagues for no reason;
- (2) teachers' interference during those moments were important to make students overcome such situations and to redirect their attention to what mattered; and
- (3) older students, such as Nathan, Albus and Darwin, were usually successful in convincing their colleagues to stop fighting [Researcher's Observation Notes, CESMAR – Socio-Educational Class].

Nathan also mentioned that they had a protocol to be followed when such confrontations occurred – which might indicate that those situations were common and that both attending and preparing those classes might have been challenging. Those confrontations might have been more frequently started by the students who did not want to be there, such as those who had no career interest related to technology and/or those attending the course under a court order. Ulrich exemplified some of the challenges as follows:

The negative aspects are the pranks (...) when someone tries to play around with the others instead of study (...) when that happens, we waste a lot of time (...) those things get in the way of the projects and our progress (...) we get stuck in one stage and can't move on.

Ulrich

As previously mentioned, Ulrich seemed to be genuinely concerned and wanted to do well, since he planned to start his own business to help his grandmother. Hence, everything that was not related to the classes/projects was perceived to have a negative impact on him. Observation data indicated that Ulrich had a strategy for those occasions: (1) he would not engage in class disruptions; (2) he would call the teacher to stop those trying to distract him; and/or (3) he would ignore his surroundings completely – except for those colleagues who shared his thoughts about the importance of performing a task or project [Researcher's Observation Notes, CESMAR – Socio-Educational Class]. Although such cultural barriers did not appear to have influenced the participants' development of career interest towards technology, it can be argued that they had enough impact for the participants to have mentioned them as factors of barriers.

The second factor mentioned by the participants was the socio-economic barriers which were represented by the lack of access to technology at home, to libraries and/or other information sources, and transportation. Darwin and Ulrich identified socioeconomic issues as possible barriers to the development of interest towards technology. The next extract presents Ulrich's account on the matter:

My uncle asked me: 'why aren't you working yet?' and my grandma replied: 'well, he asked me to attend that course at CESMAR because he wants to start his own business' (...) my uncle left me alone for a while (...) what I was trying to do before didn't work because I didn't have

enough confidence or knowledge (...) now, I can do it, when I start a project, I know I can finish it.

Ulrich

Ulrich's family seemed to have pressured him to find a job rather than studying. Ulrich's situation is not uncommon in Brazil; according to the Brazilian Ministry of Education, more than 1.3 million people between 15 and 17 years of age had abandoned school without completing their Primary studies before 2014 (MEC, 2014b). Despite being considered one of the best students in the course, his family socio-economic situation motivated him to start a business, which did not work as well as he thought it would.

However, Ulrich's former business and idea for a future enterprise are related to technology, since, as previously discussed, he intends to fix computers within his community.

Darwin also identified socio-economic factors as barriers in the development of his career interest towards technology. When asked about the possibility of attending technology-related courses somewhere other than the Centre, Darwin responded with the following:

Everything I learn here, I take notes and I practice at home. I write down everything (...) I drew a video board representing a computer screen that wasn't working. So, I practice all the steps in order to fix it (...) I write down on a piece of paper what the problem is how to fix it (...) I follow my notes
(...) Once, I drew an entire PC presenting all the problems I'd learned in class, so I could identify them and practice how to solve them.

Darwin

Darwin seemed to have made enormous efforts to overcome the fact that he did not have a computer at home on which he could practice what he had learned in class. It can be argued that Darwin's socio-economic situation, which does not allow his family to purchase a computer, might have had an impact on his education; however, it did not appear to have minimised his interest in a technological career. Both Ulrich and Darwin had been dealing with socio-economic barriers which might affect further development of such interest; in this sense, they would benefit from scholarships such as those offered within PJA.

Nathan and Ulrich mentioned health status/predispositions as barriers for the development of interest towards technology. The extracts below present Nathan's and Ulrich's perspectives on the matter:

I take a little bit longer than the others to understand things (...) I don't know why but my mother will take me to the doctor to have me tested (...) My psychologist told me my mother to take me to a doctor to get help because some people learn things slower than others (...) it takes longer for me to learn (...) They let me advance to the next year since I'm part of the project. They believe in me here [at the Centre] and I will be able to progress.

Nathan

I am not doing well at school (...) my grades are a bit below average (...) it's a little difficult sometimes. I don't have the time to study at home and I have to attend this course at CESMAR, so that's why my grades have been below average.

Ulrich

Both Nathan and Ulrich claimed to have had learning difficulties. Nathan could describe his issues and how consulting to a psychologist and the participation in a project had helped him to become more confident and, eventually, advance to Secondary School. Nathan could identify his health condition as a barrier and explained the actions that might be able to mitigate them. Moreover, observation data revealed that Nathan appeared to know how to deal with his learning difficulties during class. Nathan relied on strategies such as (1) asking the teacher's help; (2) being focused during the exercises; and (3) allowing himself to take longer than his colleagues to develop a task [Observations, CESMAR – Socio-Educational Class]. Ulrich, who presented similar learning difficulties to those of Nathan, could not pinpoint the issue or strategies on which he could rely to deal with the problem. Unlike Nathan, Ulrich lacked family or professional support and was the participant whose development of career interest towards technology could have been affected by barriers the most.

5.4.6. Within-case analysis of the development of career consideration towards technology

In order to investigate whether there was a development of career consideration towards the technology field, the Case Study 1 participants were asked to identify their career interests before attending the course and during/after the course. They were required to explain the reasons for their choices and, whenever possible, to establish a relationship between ER approaches and career consideration. Table 5.9 presents a summary of the participants' responses.

Table 5.9: Case Study 1 participants' career interests and considerations

Career Consideration	Previous career interest (unrelated to the technology field)	Previous career interest (related to the technology field)	Career consideration (unrelated to the technology field)	Career consideration (related to the technology field)
Albus	Firefighter	Game developer	-	Game designer
Darwin	Lawyer / Footballer	-	-	Software developer
Nathan	Musician / Professional Race Driver	-	-	Computer Scientist
Ulrich	Goalkeeper	Informatics Teacher	-	Entrepreneur (Informatics-related Business)

The Case Study 1 participants presented more previous interest towards fields which were unrelated to technology than those participating in Case Studies 2 and 3 (see Chapter 6 and 7). Brown (2002) argues that children and adolescents are exposed to a wide range of activities; however, it is through repeated practice, feedback and demonstration that they 'are able, gradually, to develop their skills, adopt personal performance standards, form a sense of their capability at diverse tasks' (p. 265). This argument was corroborated by the findings which revealed that the participants' career interests before the course was not technology-related whereas their career considerations, after attending the course for at least 6 months, were related to the technology field.

Albus and Ulrich claimed to have had career interest within the technology field before attending the course. Findings evidenced that the course might have helped them to remain interested in the technology field. Albus' technology-related career interest and consideration are very similar. When asked whether his participation in the course was related to his career consideration, Albus responded as follows:

I think it's 50/50. 50% is about what I'm learning here [at the Centre] about technology (...) this knowledge can help me a lot to develop my job where I'm going to work. The other 50% is about what I'll learn at the company where I'll work (...) They'll expect me to know something, which is what I'll have learned here, my knowledge about Informatics (...) they'll also expect me to learn from them. So, 50/50.

Albus

According to Albus, his participation in the course was related to his decision to change his mind from becoming a firefighter to becoming a game designer. Albus seemed to believe that employers would require a certain level of expertise (50%) from candidates in order to hire them to work at a game designing company. For Albus, the company itself would provide him with further experience and knowledge (the other 50%). Albus' inferences might have been stemmed from his participation in the course at CESMAR, since several professionals who worked within the technology field shared their experiences with the students. The next extract presents Ulrich's response to the same question:

I had an Informatics teacher at SASE and he told me that he started to teach children, develop activities, (...) he came to the CESMAR Centre (...) I wanted to be like him (...) then I thought I could start a company and help my community (...) focused on software.

Ulrich

Ulrich's previous interest in becoming an Informatics teacher seemed to have been influenced by his positive experience with Informatics as a student at the Society for Educational and Social Assistance (SASE – Sociedade de Assistência Social e Educacional). Such experience, alongside the strong role model provided by his teacher, might have influenced Ulrich's career interest (becoming an Informatics teacher) and motivated him to pursue technology-related courses at the CESMAR Centre. His experience within the Centre appeared to have had an impact on the development of his career interest and he intended to provide a technology-related service within his community – similar to those offered at CESMAR.

Nathan and Darwin changed their career consideration from fields which are unrelated to technology (respectively, musician/race driver and lawyer/footballer) to the technology field (computer scientist and software developer). When asked about

the influence of the course on that change in career consideration, Darwin and Nathan responded as follows:

I want to create a new programme like Microsoft (...) an operational system and the course helps me.

Darwin

I think Informatics is cool and interesting (...) I have been thinking about going to college and study Computers Science (...) My psychologist has recommended that too. She said that her son studied Informatics and now he makes R\$8,000 a month.

Nathan

Darwin's enthusiasm in becoming a software developer might have motivated the change in his career consideration towards the technology field whereas Nathan's reasons seemed to be both personally (he believes 'Informatics is cool and different') and financially (good wages) driven. The four Case Study 1 participants changed their career considerations after attending the Socio-Educational Course for at least 6 months. Findings revealed that such changes might have been motivated by (1) their positive experiences at the Centre; (2) knowledge and skills developed during the course; and/or (3) financial gains prospectus. Hence, it can be argued that course curriculum providing the students with mixed ER approaches (ER projects, classes and competitions) helped the students to be reassured about or influenced the students to change their career consideration towards technology.

The next section analyses the development of confidence towards technology, an important factor on the development of vocational interest or vocational behaviour.

5.4.7. Within-case analysis of the development of confidence towards technology

Confidence towards technology was the last factor analysed in terms of its contribution to the Case Study 1 participants' development of career interest. Given the significance of this attitudinal factor in helping one's process of developing career interest towards a certain field, investigating whether the students developed confidence in their skills related to handling, building and programming robots was

important for the development of this study (Brown, 2002). Table 5.10 presents a summary of the findings regarding confidence towards technology.

Table 5.10: Case Study 1 participants' development of confidence towards technology

Confidence towards technology	Have not changed	Have changed positively	Have changed negatively
Albus	-	X	-
Darwin	-	X	-
Nathan	-	X	-
Ulrich	-	X	-

Interview and observation data revealed that the four participants' confidence towards technology increased. Participants' teachers highlighted that the students' confidence 'usually increases after they have been handling robotics and informatics equipment for a while' [Interviews with Teachers, CESMAR – Socio-Educational Class]. Observation data evidenced that a positive environment, where the students could be creative and trust in their abilities, had been created by the teachers [Observations, CESMAR – Socio-Educational Class]. Thus, it can be argued that such environment might have contributed to the students' positive change regarding their confidence towards technology.

As previously discussed, Ulrich claimed to have changed his view about what the course could offer him in terms of learning experiences. Ulrich, who would use computers solely to play games, started to understand the learning potential that the use of computers can offer. In this sense, the course has impacted on Ulrich's learning process towards technology. Albus and Darwin also used to be exclusively interested in games; however, according to them, the teachers' work at the Centre guided their attention towards other aspects of technology – such as Robotics and Electronics.

Nathan, in turn, seemed to have taken longer to start developing confidence towards technology – as the following extract suggests:

I learned more about it [technology] here [at the Centre] (...) I thought I'd never be able to learn anything about Informatics (...) I used to think that everything was too complex and too hard for me to learn, but, today, I master everything.

Nathan

Nathan's account exemplified his progress in terms of developing confidence towards technology – from thinking he would never learn to claiming to 'master everything'. Considering Nathan's awareness of his learning difficulties as barriers for his progress (see Section 5.2.5 for further details), his participation in the course appeared to have developed his confidence. Nathan's progress was not acknowledged only by Nathan himself, teachers and staff at the Centre seemed to share his opinion, since Nathan had just been granted a scholarship from PJA in order to continue his studies. Feeling supported by his teachers and having his efforts rewarded might have helped to increase Nathan's confidence towards technology.

Although the participants associated technology to the topics within the course curriculum rather than equating technology to their daily lives, Darwin's confidence towards technology seemed to have a deeper meaning, as he explained in the following quote:

I used to learn different things at SASE: capoeira, culture and things like that, but here [at the Centre] I started to develop as a person a little bit more.

Darwin

Darwin, who was interested in software development before attending the course, appeared to have developed more than confidence towards technology. For Darwin, his participation in the Socio-Educational Course represented a personal development as well – which he did not have experience when he attended afterschool projects that were unrelated to technology. Moreover, Darwin seemed to understand that his personal development was a process, since he claimed to have 'started to develop'.

This section has analysed the development of the Case Study 1 participants' confidence towards technology. The four participants claimed to have developed more confidence towards technology *after* having started attending the Socio-Educational Course. Teachers' and staff members' efforts were recognised to be important factors for the development the students' confidence – especially for Nathan and Ulrich.

5.5. Conclusion

This chapter has analysed the development of career interest towards technology based on the SCCT model (Lent et al., 1994). The initial hypothesis of this study was that, after a period of at least six months attending to the Socio-Educational Course at the CESMAR Centre, the Case Study 1 participants would have developed, to a certain extent, career interest towards technology. A framework informed by the SCCT model of basic development of career interest considered factors, such as self-efficacy, outcome expectations, interest, goals, to investigate the participants' career interest development. Factors of barriers and supports and confidence towards technology were also analysed to establish their potential impact in the development of those participants' career interest.

Findings revealed that the four participants (1) developed, to some extent, an interest in technology careers; (2) continued to achieve positive performance within the technology-related course; and (3) demonstrated attitudinal changes (confidence towards technology). Table 5.9 summarises the findings concerning the Case Study 1 participants after the triangulation involving data gathered from the different methods applied. The supporting factors identified by Albus and Darwin seemed have influenced the development of their career interest towards technology in a more significant way than the reported barriers. Such argument can find support in the fact that both students presented positive performance and had the intention to continue attending other technology-related courses at the Centre.

Nathan has been found to receive outstanding support from family members, mental health professionals, teachers and staff at the Centre. Thus, despite the barriers that were identified by him – especially those related to his learning difficulties – Nathan also presented positive performance and the desire to continue his studies within the technology field. Ulrich, whose factors of barriers were found to surpass supporting factors, presented an interest towards technology careers. However, it can be argued that those barriers might have a bigger impact in Ulrich's interest than the supporting factors, since Ulrich was the participant who mentioned his desire – necessity even – to start working soon.

Table 5.11: Summary of the findings regarding Case Study 1

Participant/ Factor	Albus	Darwin	Nathan	Ulrich
Self-efficacy	*Informatics-hardware (assembling) *Programming (Minecraft) * Arduino * Scratch * OS's	*Informatics *Programming (Scratch) *Software installation	*Informatics *Programming *Robotics	* Programming (S4A) *Arduino *Engineering *Electronics *Electronics with Arduino
Outcome expectations	*Positive feedback from teachers; *Positive outcome expectations towards Arduino and informatics	*Positive feedback from teachers and colleagues regarding Informatics; *Positive appraisal regarding Scratch (S4A)	*Stemming from his successful performances	*Stemming mainly from teachers' appraisal
Interest	*Software development and game design	*Software development / programming *Informatics	*Software development	*Informatics *Engineering Skills
Goals	*Continuing to attend technology courses (through YAP and outside CESMAR); *Create a game	*Attending another technology-related course; *Starting his own business	*Attending another technology-related course (with a YAP scholarship); *Applying for college (Computer Science)	*Starting his own Informatics business
Career consideration	*Game designer	*Software development * Informatics entrepreneur	*Computer Scientist	*Informatics-related entrepreneurship
Broaden view of labour market	*Contact with software development students/teachers; *Contact with other role models in the technology field	*Contact with software development professionals	*Contact with professionals (teachers); *Studying topics which helped him learn more about the technology field.	*Opportunities provided by CESMAR to learn more about the Robotics field and careers related to IT and technology education field
Barriers	*Lack of equipment to practice at home; *Chatting in excess with colleagues during classes	*Impossibility to attend a paid course; *Lack of financial support; *Lack of equipment to practice at home; *Lack of access to information (e.g. libraries, Internet, book shops)	*Learning difficulties; *Violent and/or distracting situations during classes	*Family pressure to start working; *Violent and/or distracting situations during classes; *Learning difficulties; *Lack of equipment to practice at home *Lack of access to information (e.g. libraries, Internet, book shops); *Lack of family support
Supports	*Excellent family support (e.g. sisters are former CESMAR students); *Structural support provided by CESMAR (e.g. availability of other courses, access to internet and equipment)	*Emotional support from family; *Structural support provided by CESMAR (e.g. availability of other courses, access to internet and equipment)	*Support from teachers to complete Primary School; *Psychological support from mental health professionals; *Family support (emotional and financial); *Access to technology at home (e.g. computers, internet) to practice	*Structural support provided by CESMAR (e.g. availability of other courses, access to internet and equipment)

CHAPTER 6 FINDINGS – PART II

6.1. Introduction

This section reports the findings of the Case Study 2 which, mirroring Case Study 1, focused on the SCCT framework of development of career interest towards technology according to Lent et al. (1994). Firstly, the preferred ER approach used within the courses is presented. Then, factors related to self-efficacy, outcome expectations and choice goals are discussed in terms of their relationship with the development of the participants' interest towards technology. Additionally, supporting and factors of barriers are analysed alongside the development of the participants' career considerations and confidence towards technology. Finally, initial conclusions concerning the findings regarding Case Study 2 are drawn.

6.2. Case Study 2: Electro-electronics Courses / CESMAR Centre

The Electro-electronics course at the CESMAR Centre started in 2013 and they aimed to provide students with a two-years course focusing on Robotics. The course curriculum (Appendix III) comprises basic topics of Informatics, Electronics, Electrics and Robotics (using mainly opens-source kits, such as Arduinos and Raspberry Pi's). In order to be able to participate in projects, competitions and classes, the students are required, at the end of the course, to apply, in teams, what they have learned by (1) developing a device; (2) programming it; and (3) presenting a final paper about the entire experience. This format intends to replicate the requirements of undergraduate courses in Engineering and Computer Science, for example. Table 6.1 below highlights some demographic details about this case study's participants.

Table 6.1 – Demographic details about case study 2 participants

Educational Settings	Students	Gender	Age	Level of Education
CESMAR Electro-Electronics Course	Michelle	Female	19	3 rd year/Secondary School
	Anne	Female	19	Post-Secondary School
	Ethelyna	Female	19	2 nd year/Secondary School
	Luisa	Female	19	3 rd year/Secondary School
	Andrea	Female	20	2 nd year/Secondary School
	Amelia	Female	21	Post-Secondary School

Data was gathered for the investigation in this educational setting as described in the table below:

Table 6.2 – Data Collection Timeline

Activity	2015			2016											
	Oct	Nov	Dec	J	F	M	A	M	J	J	A	S	O	N	D
Monthly reports from teachers (from 01/10/2015 to 29/04/2016)															
Participant observations (from 26/10/2015 to 13/11/2015)															
Researcher's field notes (from 26/10/2015 to 13/11/2015)															
Monthly individual's interviews with participants (from 01/12/2015 to 29/04/2016)															
Monthly follow-up interviews with teachers and tutors (from 01/12/2015 to 29/04/2016)															
Focus group interviews during fieldwork (from 26/10/2015 to 13/11/2015)															
Analysis of documents from students (from 26/10/2015 to 29/04/2016)															

The electro-electronics course shares several characteristics with the Socio-Educational course (see previous chapter), such as location and students' demographics. This course was created within CESMAR in 2013 and it was developed to be a 2-years course for which students who were 18 years old or above (and were studying or had finished Secondary School) could apply. The electro-electronics course aimed to broaden the range of professional training activities which had been provided by CESMAR. Thus, the course is different from other courses which had been available – such as the Computer Repairing Course and the Software Development – for targeting 'professionally qualify young people in areas such as Electrics, Electronics, Automation and Robotics through full-time schooling, enhancing their social condition as well as promoting their entry into the labour market' (Broc, 2013, p.1).

The course also aimed to offer professional training in the technology field (e.g. informatics, robotics, programming) to a portion of society whose social and economic disadvantage can prevent the access to Higher Education [Interview with the Teachers at CESMAR]. In this sense, it seems that the course co-ordinators' main goal was to provide the students with a certificate which might help them to apply for jobs within those fields. In addition, the students would also be able to apply for places at universities through one of the federal government programmes (e.g.

ProUni). Hence, that course offers more than an afterschool activity or full-time schooling; it provides technology-related professional training.

The electro-electronics course was comprised of 20-hours-a-week activities for the period of 23 months. Amongst the methods of assessment, the following were the most significant: tests; oral presentations; and hands-on activities (such as assembling, testing, configuring, installing systems and practising with hardware/software). Three ER approaches were developed during the course: ER classes (such as Arduino and Raspberry Pi), ER projects (the final assessment consisted in the development of an entire project) and ER competitions (which included the FRC, MOSTRATEC and others).

As part of the courses which participated in PJA, the students were eligible for scholarships and signed professional contracts with the companies that sponsored their studies. As apprentices within those companies, the students had to perceive their studies at CESMAR as their jobs under all the legal rights that had been included in their contracts – such as a monthly salary, 30-days annual leave and any other rights that are reserved to workers according to the Brazilian Constitution (see Brasil, 1988). The course started in 2014 with ten students who had met all the requirements related to age, level of education, agreement regarding the professional contracts. All ten students (eight females and two males) had agreed to participate in this study; however, only six (all females) of the ten students started the second year of their studies and therefore continued to participate in this study until its conclusion. The main reasons why those four students did not complete their studies were related to opportunities of employment that offered a higher income than that on which they could rely by participating in PJA. Due to the reduced number of students that remained for the period of 2014-2016, changes were made in the course curriculum which became a one-year course in 2016.

6.3 Analysis of development of technology skills in case study 2 participants

The Case Study 2 participants had a curriculum which encompassed more learning opportunities to develop technology skills than that within the Case Study 1 context. Figure 6.1 presents the technology skills developed by the Case Study 2 participants.

Figure 6.1: Technology skills developed by the Case Study 2 participants

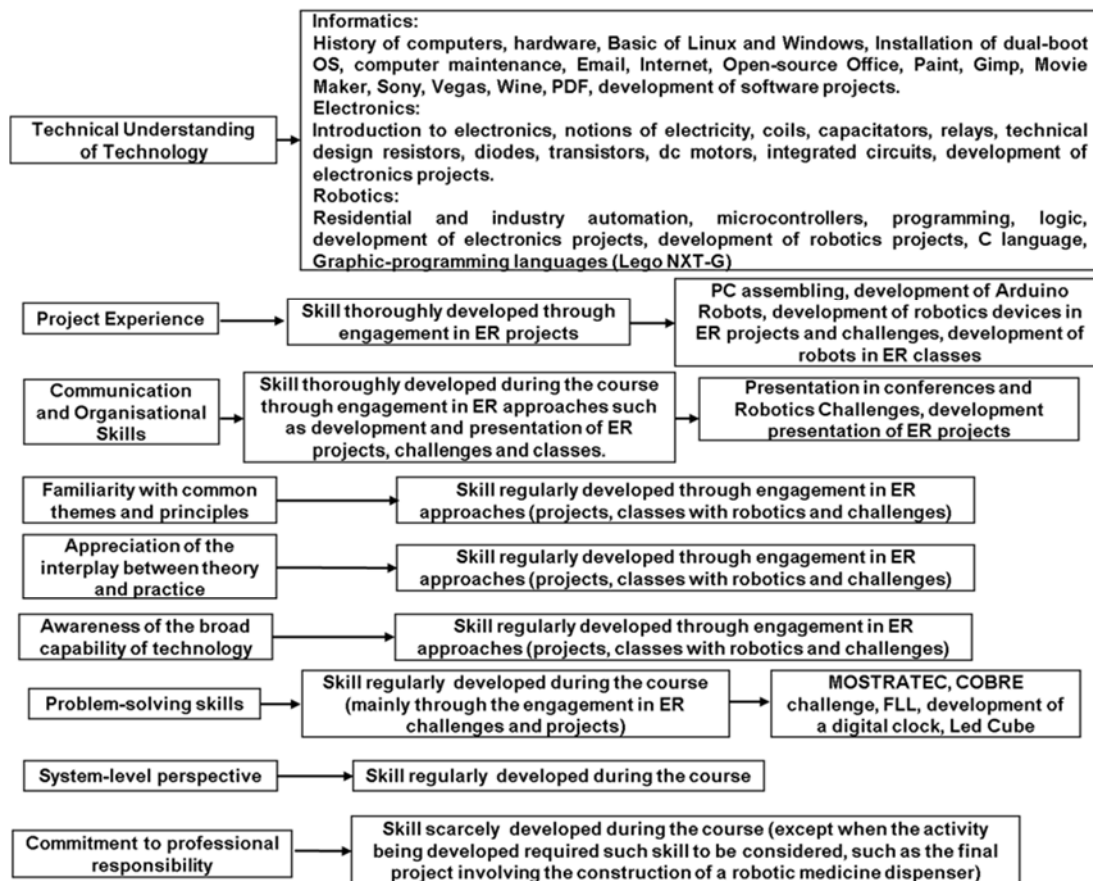


Figure 6.1 highlights that the Case Study 2 participants had a balanced amount of technology content within their course curriculum, since a third of the course was dedicated to each one of the three fields – Electronics, Informatics and Robotics. Such balance reflected the curriculum which had been developed to prepare professionals for the multidisciplinary automation field. The students were provided with many opportunities to develop project experience and communication and organisational skills through the three ER approaches on which the course had been based. Such approaches were found to have helped the case study 2 participants to develop technology skills related to (1) problem-solving; (2) system-level perspective; (3) awareness of the broad applicability of technology; (4) familiarity with the common themes and principles of technology; and (5) appreciation between theory and practice.

Commitment to professional responsibility, however, was found to have been advanced scarcely throughout the course. The only opportunity that the participants seemed to have had to exercise such skill was when they were required to work on

an ER project during which they had to recognise sociocultural and ethical issues inherent to the development of robotics devices. For example, one of the robotics devices, a medicine dispenser, was constructed after a market research had revealed that the cost of the industrialised devices was too high for the population living within the CESMAR is district. The team, comprising Anne, Ethelyna and Michele, decided to build the device for less than half its market cost using mainly recycled computer parts.

The next section analyses the development of interest in technology careers in case study 2 participants.

6.4. Analysis of development of career interest in technology in case study 2 participants

In the following sub-chapters, factors that influence the development of interest in technology careers according to the SCCT model (Lent et al., 2002) are analysed. In the final sub-chapter, the extent to which career interest was developed by each participant in case study 2 is examined, according to that model.

6.4.1. Within-case analysis of self-efficacy

As previously discussed in Chapter 2, one's positive and negative self-efficacy beliefs might influence the development of one's career interest. According to Lent et al. (1994), positive self-efficacy beliefs can lead to the development of interests, choice goals and actions whereas negative self-efficacy tend to undermine such factors. Table 6.3 identifies the sources of self-efficacy according to the Case Study 2 participants. Those considered to be negative self-efficacy beliefs by the participants have been underlined.

Table 6.3: Sources of self-efficacy beliefs according to the Case Study 2 participants

Self-efficacy	Personal Performance Accomplishments	Vicarious Learning	Social Persuasion	Physiological and Affective States
Amelia	Robotics Electronics <u>Programming</u>	Teachers and Colleagues	-	-
Andrea	Electronics Engineering <u>Programming</u>	Experts	-	<u>Nervous</u>
Anne	Informatics Electronics Engineering Robotics	Teachers	Teachers	<u>Nervous</u> and Persistent

Ethelyna	Informatics Electronics Engineering <u>Programming</u>	Colleagues, Teachers and Experts in the field	-	<u>Nervous</u> and Focused
Luisa	Informatics Electronics Robotics Engineering <u>Programming</u>	Teachers and Colleagues	-	<u>Nervous, Angry</u> and Persistent
Michelle	Informatics Robotics Electronics Programming <u>Engineering Skills</u>	Teachers	-	Focused and <u>Irritated</u>

The Electro-electronics course provided the students with opportunities to be involved in learning experiences at the Centre and other relevant places – such as robotics competitions, conferences, guided visits to automated industries. Brown (2002) argues that successful learning opportunities tend to influence positively one's self- efficacy whereas unsuccessful and/or frustrating experiences might have a negative impact. Findings revealed that Personal Performance Accomplishments were the most significant sources for the Case Study 2 participants. Three topics belonging to the course curriculum were mentioned by the students: (1) Informatics, which includes, learning about operational systems, hardware, software and programming; (2) Electronics (involving components, testing and circuits); and (3) Robotics (comprising open-source kits, Lego, graphic interface and the development of prototypes development). Specific aspects related to those three key topics, such as engineering skills and programming, were also identified as sources of self- efficacy.

The participants' accounts supported their claims regarding their career interest towards technology (see Section 6.2.1.7 for further details). The extract below exemplifies such arguments:

I really like the Clock Project (...) I enjoyed taking them to GHC because they are a company that can offer financial contributions, so we're allowed to be here [at the Centre] as their apprentices (...) we developed the Clock Project, spread the clocks around CESMAR (...) then GHC asked us to take some of the clocks to them so they could display them there [at GHC].

Ethelyna

The Clock Project, to which Ethelyna referred, combined Electronics and Robotics and involved the development of clocks using recycled materials that the Centre had been receiving through assorted partnerships. For that project specifically, the students could use, amongst other materials, slot machines which had been confiscated by the Federal Police and donated to CESMAR [Researcher's field notes, CESMAR Centre, Electro-electronics Course]. Ethelyna's account suggested a personal performance accomplishment – being able to build a clock – that is related to an affective state – feeling proud of herself for having her work acknowledge by a company. Michelle's quotation below presents her account regarding her self-efficacy beliefs.

Programming makes me feel proud of myself because I'm the person who does the best codes here [at the Centre] (...) people always ask my help like "hey, Michelle, I don't know how to do this or that" (...) it's something I really like doing and I always do well performing those tasks, I think, and the other girls also think that.

Michelle

Despite having mentioned other areas (e.g. Robotics, Electronics), Michelle seemed to have identified programming as a Personal Performance Accomplishment. Michelle also related her accomplishments in programming to social persuasion, since her colleagues' acknowledgment appeared to have influenced her to engage in the development of more complex tasks.

Vicarious learning was identified by the Case Study 2 participants as an important source of self-efficacy beliefs, which corroborates the arguments from Brown (2002), who also indicates the same potential for self-efficacy. According to Lent et al. (2002), watching peers perform successfully can instigate one's awareness about one's efficacy and that of others. The Electro-electronics Course at the Centre provided the participants with opportunities of direct and indirect vicarious learning experiences (e.g. classes, projects, competitions, conferences). For example, the teachers who had been selected to teach this course were former students at the Centre, which aimed to impact the students' perceptions about professional role models. In so doing, students might be able to relate to the teachers' journey from being a student at the Centre themselves to having a career within the technology field and become more motivated [Interview, CESMAR Centre,

Department of Social Assistance]. As a result, five of the six students mentioned their teachers as a source of vicarious learning. The next extracts exemplify the students' perceptions on the matter:

My teachers say "Guys, even when something doesn't work, you can't give up...not after the first attempt, ok? (...) I live by it, you know, that you can't give up on things easily (...) watching my teachers also help me learn, but only my teachers because my colleagues lose their temper easily.

Anne

I confess that I learn a lot only by observing everyone in class (...) when I'm about to have a test, for example, I give a last try by studying the content for the last time and trying to remember what I observed (...) the more I practice, the better.

Luisa

The quotations suggested that in-class vicarious learning experiences stemmed from both teachers – in Anne's case – and teachers and colleagues – in Luisa's case. Moreover, the students seemed to have perceived vicarious learning to be a positive source of self-efficacy. However, despite having been identified as a positive source of self-efficacy, vicarious learning stemming from colleagues can also play a negative role. For example, in the next extract, Amelia, whose self-efficacy beliefs towards her programming skills were identified as negative, attributed a positive aspect to the vicarious learning experiences regarding programming that she had had.

The boys who attended classes with us were calm and they used to help us a lot (...) the teachers can teach but there's always someone closer who can help (...) one boy helped me to develop programming skills (...) we used to just observe one another to learn how to do things instead of reading the materials (...) the teachers would tell us "read the books", but we only observed the others (...) tried on our own or waited until one of the boys could help us.

Amelia

Amelia suggested that programming was a task which would be mainly performed by the male students who used to attend the Electro-electronic class. Moreover, it seemed that the female students, except for Michelle, who had previously claimed to be an excellent programmer, relied on the male students' help rather than on the learning materials (handouts including C++ lessons for Arduino/Raspberry Pi and

graphical interfaces such as S4A and Lego). Although peer observation and collaborative work tend to be encouraged within the Centre [Interview with Social Assistant, CESMAR Centre], such practice appeared to have delayed the development of female students' programming skills – since four of the six participants identified programming as a negative source of self-efficacy.

Social persuasion can reassure and/or convince people about their abilities to develop successfully a certain job, (see Athanasou and Van Esbroeck, 2008; General et al., 1989; Lent and Worthington, 2000). For Bandura (1994), people who are convinced by a third party that they can master a specific task are likely to succeed. Despite the importance attributed to this factor, only Anne identified social persuasion as a source of self-efficacy. Given that Anne argued that the teachers were her main source of vicarious learning, it is not surprising that the teachers' support and/or appraisal represented, for Anne, positive social persuasion.

Observation data evidenced that the teachers' support was important for the students to be more confident in their skills and abilities. For example, during the competition MOSTRATEC-2015, after having practiced for over two months, the robot, which had been developed quite well for the challenge, started presenting some electrical malfunction. That episode might have had a negative impact on the students' confidence towards their knowledge about Robotics, since they could not find a reasonable explanation or a solution for the malfunction. The teachers encouraged the students to Michelle, Anne and Ethelyna to use a spare robot and do their best with what they had. [Observation notes, CESMAR Centre, Electro-electronics Class]. Despite having benefitted all three students, the teachers' support was identified as positive social persuasion only by Anne.

Physiological and Affective States, which is another source of self-efficacy that can affect – even if not as much as those previously mentioned – the development of one's interest in a given task, was also emphasised by five of the six participants in Case Study 2. Physiological and emotional states, such as those emerging from situations where one is under pressure or tense, tend to be perceived as factors which might affect one's performance (Lent et al., 1994). Interview data and observation data originated different findings regarding the influence of Physiological and Affective States in the Case Study 2 participants' performances.

Anne, Andrea, Ethelyna and Luisa claimed to have felt nervous, an emotional state identified as negative, while trying to solve robotics-related problems. Anne, Ethelyna and Luisa stated that persistence and focus, emotional states identified as positive, helped them to overcome nervousness. When asked about how she feels during a situation similar to the robot-malfunction episode, Anne responded that, despite feeling nervous, she keeps such feelings to herself, concentrates and continues developing the task [Interviews, CESMAR Centre, Electro-electronics Class]. Andrea did not present any strategy to overcome her negative emotional state. Michelle also mentioned focus as a positive emotional state; however, Amelia did not identify Physiological and Affective States as a source of self-efficacy. The next section focuses on the analysis of the Case Study 2 participants' outcome expectations.

6.4.2. Within-case analysis of outcome expectations for the Electro-electronics class

Positive outcome expectancy can lead to development of interests, choice goals and choice actions and the sources of outcome expectations might vary from one individual to another (Athanasou and Van Esbroeck, 2008). Such argument was corroborated by the Case Study 2 participants' accounts regarding the matter. Table 6.4 presents the four sources of outcome expectancy, which are part of the SCCT model, that were identified by the participants (Brown, 2002). Observation of the outcomes, which was mentioned as a source of outcome expectations by the Case Study 1 participants (see Chapter 5 for further details), was not identified by the Case Study 2 participants. Possible reasons for that omission are discussed in Chapter 8.

Table 6.4: Sources of outcome expectations according to the Case Study 2 participants

Outcome Expectations	People's Appraisals	Attention to self-generated outcomes	Sensitivity during Task Performance	Self-efficacy Influence
Amelia	X	X	-	X
Andrea	X	X	X	X
Anne	X	-	X	X
Ethelyna	X	X	X	X
Luisa	X	X	-	X
Michelle	X	X	-	X

According to Brown (2002), people's appraisal usually represents people's judgement and/or assessment of a certain outcome. All the Case Study 2 participants identified people's appraisal as a source of outcome expectations, since the six students claimed to have had their development and achievements acknowledged frequently by the teachers at the Centre, competition judges, family members, friends and colleagues. However, for some students, such positive source of outcome expectations did not help the development of goals, choice actions and interest towards technology, as is further discussed in the following sections.

The extract below presents Andrea's account on the impact that people's appraisal had in her progress within the Electro-electronics course.

I liked to make the digital clocks (...) mine is at our classroom (...) my project turned out to be a very good one (...) the teacher said that the really good ones would be given to the companies sponsoring us, so he took mine to one of those companies (...) During the challenge Aline's team ended in 1st place and my team only won the engineering prize (...) there was a bridge which increased the computer's stability, but it was still a little unstable and our robot was not able to do everything we were supposed to do.

Andrea

Andrea's quotation suggested that the acknowledgement of the good results originated from the Clock Project went beyond the teachers at the Centre. The clocks made by the students had been displayed around the common areas within the CESMAR Centre by members of the staff. While the clocks were being exhibited around the Centre, representatives of the companies with which some of the students had an apprenticeship agreement, visited CESMAR and praised the students' achievements. The clocks were, therefore, donated to companies by the students who, during their visit to the companies, had their photos taken in order to be displayed at the Centre and motivate other students [Researcher's field notes, CESMAR Centre, Electro-electronics Class].

Andrea shared another accomplishment of hers when her team performed at a competition event. According to Andrea, although their robot had presented some issues, her team was awarded with the engineering prize. Such appraisal might have been especially meaningful to Andrea, since she claimed to perceive Engineering to be one of her Personal Performance Achievements [Researcher's field notes,

CESMAR Centre, Electro-electronics Class]. The thread connecting outcome expectations, learning experiences and sources of self-efficacy that Andrea seemed to have intertwined corroborates Bandura's (1989) argument that outcome expectations might stem from learning experiences and lead to the development of interests, choice goals and actions towards a topic/area in which one is likely to succeed.

Attention to self-generated outcomes was identified by five of the six Case Study 2 participants as a source of outcome expectations. Attention to self-generated outcomes usually involves self-approval, others' response to one's actions, personal satisfaction for mastering a certain activity/task (Lent et al., 1994). The accounts below present examples of the participants' perspectives on the matter:

I keep everything I learned in my head (...) I would be able to build the clock again, programme it and all, I could do it.

Anne

There are a lot of difficult things to do (...) programming, for example. I can fix everything, paint, cut, but programming is quite a lot. It's difficult for me. I don't like to spend much time in front of a computer (...) I'm not this kind of person.

Luisa

Anne's claims that she could replicate and/or develop by herself the projects on which she had previously worked at the Centre indicate her self-approval. Luisa, in turn, believed that she could do anything but programming. Although programming seemed to represent an academic barrier to all the participants, except Michelle, the six students had developed complex robotics projects (e.g. digital clocks, open-source robots, led cubes, automatic medicine dispenser, automatic object-detectors for visually impaired people) which involved significantly complex levels of programming. Luisa did not claim that she did not know how to programme; she stated that she did not like programming and that she enjoyed developing other tasks (e.g. designing). Thus, findings revealed that most of the Case Study 2 participants knew how to programme but did not enjoy it or preferred not to be responsible for this aspect of the projects.

The negative outcome expectation belief towards programming might be a result of the type of ER approach on which the tasks within the course were based. Luisa,

Amelia and Andrea did not want to participate in ER competitions which involved pressure and limited time to achieve a certain outcome (e.g. to make the robot perform all the predetermined tasks within two minutes). Luisa, who had identified ER as a tool in learning and ER projects as her preferred approaches, described an ER project as the approach which helped her to achieve self-approval. This approach, as previously explained, allows the students to have more time to research, to rely on the teacher and peer support and to develop the task thoroughly until the desired goals can be accomplished.

Sensitivity to physical cues during task performance was identified by three of the six participants as a source of outcome expectations. This source, which refers to beliefs regarding issues such as levels of emotional arousal and/or well-being, can stem from learning experiences that also affect self-efficacy beliefs (Brown, 2002). Ethelyna, Andrea and Anne claimed to have experienced levels of emotional arousal and/or well-being while performing one of the ER approaches developed in the Electro-electronics Course. The next extract presents Andrea's account on the matter:

When I have to programme, I feel nervous, but, when I have to develop a task like the one with the digital clocks, I remain calm because the teachers allow us to take our time to do it and there's no pressure.

Andrea

Andrea addressed, again, the importance of having enough *time* to develop a given task, which might have influenced her preference towards ER project rather than ER competitions as an ER approach. Although Andrea claimed that programming made her nervous, the Clock Project, that involved programming the Arduino board to control the hours, minutes and seconds, was mentioned as a project with which she seemed to have felt comfortable. In this sense, programming, as part of an ER project, did not seem to cause a negative effect on Andrea as programming during an ER competition. Ethelyna, as the following quotation evidence, appeared to have felt more comfortable with ER competitions.

I like this competition thing very much. This is one of the things that I like the most in this course. Michelle and Anne also like it and I think that Vitoria [their supervisor], who's not a student in this course but is always helping us, likes it too. She was in one of the teams, last year.

Ethelyna

Ethelyna explained that only half of the group liked ER competitions, and, for that reason, the three students worked together as a team. The aim was to be prepared to perform during MOSTRATEC 2015 [Researcher's field notes, MOSTRATEC, Electro-electronics Class]. Ethelyna seemed *confident* and *positive* about her abilities to perform a role within the robotics team. Observation data evidenced that Ethelyna was focused during the entire 2-days event (9 hours per day). Ethelyna's teammates, Anne and Michelle, as well as their supervisor, remained calm and determined to solve an unanticipated problem with their equipment which forced them to change the hardware and code during the event. Their efforts enabled them to achieve an intermediary position, which they perceived to be a considerable achievement, since most of the teams seemed to have focused on the code rather than the hardware [Researcher's field notes, MOSTRATEC, Electro-electronics Class].

Self-efficacy influence is a source of outcome expectations that can be influenced by self-efficacy when outcomes are determined by the quality of one's performance (Brown, 2002). All the Case Study 2 participants identified self-efficacy influence as a source of outcome expectations; in other words, they recognised the impact of their previous performances in their capacity to perform further tasks. The following extracts clarify the participants' perspectives:

What we've done once we do better a second time...and even neater.

Luisa

I really like welding and using the cutting machines. I like this part. What I don't like is programming. It's complicated and I don't like (...) There was a competition, so Amelia, Luisa and I designed and built the car and the other girls did the coding.

Andrea

Luisa, as well as the other participants, claimed that she could improve her performance if she developed any task for the second time. However, according to Andrea, programming was a complicated task for which none of her teammates, including herself, wanted to be responsible; such a belief might have been influenced by the impact of self-efficacy regarding her programming skills. It can be argued that

the three participants did not necessarily lack the capacity to programme, but the personal preference towards it; moreover, observation data revealed that the participants had issues with the teaching approach. The students attending the Electro-electronics course had been instructed to use exclusively the handouts provided by the teachers for consultation about programming instead of searching online for examples of programming. [Researcher's field notes, CESMAR Centre, Electro-electronics Class]. Interview data evidenced that the teachers' goal with this approach was to nurture the students' creativity and simplicity, since all activities developed referred to the handout [Interview with teachers, CESMAR Centre, Electro-electronics Class]. The teachers' attempt to limit the students' consulting sources seemed to have had a negative impact on some of the participants' confidence in their programming skills and choice goals/actions towards technology.

This section has focused on the sources of outcome expectation beliefs identified by the Case Study 2 participants. Based on the SCCT theory, one is less likely to develop interest in actions if one's self-efficacy towards it or outcomes is unanticipatedly negative (Brown, 2002). Findings showed that the Case Study 2 participants' outcome expectations beliefs and personal positions seemed to have intertwined and been influenced by students' opinions about their academic strengths. For example, despite having claimed to be able to reproduce the tasks that they had already performed during the course, most of the participants stated that they did not or would not enjoy being responsible for programming. The next section discusses the findings related to choice goals towards technology.

6.4.3. Within-case analysis of choice goals towards technology

Choice goals can be perceived as one's resolution to be involved in a specific activity (Bandura, 1989). Choice goals are, therefore, organised, guided and maintained by an individual who behaves in a certain manner without external reinforcement (Brown, 2002). The Case Study participants were able to identify three types of goals involving the technology field: (1) academic in a technician level; (2) academic in a higher level of education; and (3) career-related. Table 6.5 shows the participants' choice goals.

Table 6.5: Case Study 2 participants' Choice Goals

Participants	Academic: Technical level of education	Academic: Higher level of education	Career-related	Choice actions
Amelia	-	-	-	-
Andrea	-	-	-	-
Anne	-	-	X	-
Ethelyna	X	-	X	-
Luisa	-	-	X	-
Michelle	X	X	X	X

Amelia and Andrea did not identify goals towards the technology-related field (see Chapter 8 for further details) whereas the other four participants selected, at least, career-related choice goals. Michelle explained what had motivated her to go back to CESMAR, in 2016, as follows:

Because I've been working with those people (...) I want to participate in a robotics competition again, but, because I'll be graduated next year [2016] (...) maybe I can come back and participate as a supervisor.

Michelle

Michelle expressed her wish to participate in MOSTRATEC 2016 as a supervisor, since she would have concluded the Electric-electronic course. Ethelyna also intended to participate in MOSTRATEC and Lego FRC [Researcher' field notes, CESMAR Centre, Electro-electronics Class]. Furthermore, Michelle, alongside Anne, identified higher education as a choice goal. Michelle's desire to go to college in order to study Computer Science was explained as follows:

I think programming is the connection between the Electro-electronics course and my interest in Computer Science (...) I think that's how I learned that I was good at programming. I really like to sit there and solve problems instead of standing there building this or that.

Michelle

Michelle could establish a connection between her participation in the course at CESMAR and her higher education-related choice goal. Michelle believed herself to be good at programming and seemed to have chosen Computer Science so that her programming skills can be improved during her undergraduate studies. Anne, in turn, claimed that she preferred to improve her knowledge regarding hardware and,

therefore, Engineering appeared to be more suitable as a higher education-related choice goal. Anne's choice might have been influenced by her positive self-efficacy beliefs towards Engineering and Robotics and a job opportunity within the Electronics field [Interview, CESMAR Centre, Electro-electronics Class].

Career-related choice goals, which entail the purpose or the intention to be involved within the technology field because of participation in the Electro-electronics course, were highlighted by four of the six Case Study 2 participants. The participants stated that finding a job within the technology field, after having concluded the course, was the goal or the means to the goal. For example, Luisa, in the extract below, explained her career-related choice goals to be achieved while attending the course at CESMAR:

I think it's going to be hard, but (...) there's the supervisor job related to the technology field here [at the Centre] (...) and you deal with a lot of technology while supervising the students who are developing their projects (...) I think I'd be good at that, supervising and advising students regarding technology, I mean, not at technology itself. Helping people how to achieve something, how to get things organised (...) I like the "organising" and "advising" bits.

Luisa

Luisa seemed to have decided to apply for the supervising job at CESMAR, which involves helping the students attending the Electro-electronics course. The quotation suggests that Luisa believed she had the necessary skills to develop the supervising job and, as discussed in Section 6.2.1.7, her primary career interest was related to teaching. In this sense, it can be argued that Luisa's career-related choice goal was a means to achieve a further goal. Ethelyna. Anne and Michelle also identified career-related to the technology field as choice goal as exemplified below by Anne's account.

The course's helped me in understanding aspects of electronics that I didn't know before (...) it makes me want to continue in the field (...) my cousin, who's already working with Electronics and building boards for components, invited me to work at his company after I complete the course.

Anne

Anne seemed to have chosen a career-related goal because of the positive self-efficacy beliefs that she had developed during the course at CESMAR and a job offer in the field. Michelle's reason for choosing a career-related goal appeared to have been influenced by her more immediate needs, which involved helping with the family budget [Interview, CESMAR Centre, Electro-electronics Class].

Choice actions comprise one's determination to get involved in a specific activity or to achieve a certain goal (Bandura, 1989). The most significant difference between choice goals and choice actions is that choice actions implicate a real action towards the development of career interest in technology. Michelle was the only Case Study 2 participant who identified a choice action towards the technology field. The following extract presents Michelle's account on the matter:

I'm interested in many things (...) before the course [at CESMAR] I wanted to go to medical school (...) then I wanted to attend a course in the Informatics field, which I've always liked it a lot (...) after that, I wanted to study Civil Engineering (...) while attending a Career Day at PUCRS [Catholic University located in Porto Alegre/RS/Brazil] (...) I went to the Civil Engineering stands, Mechanical Engineering stands, Electrical Engineering stands (...) I wanted to learn about several courses available
(...) but it wasn't for me at all (...) because I was good at programming, mathematics, these kinds of things, I wanted to study something related to those things (...) I was thinking about studying Computer Sciences (...) I still think about it, but I'm not sure yet.

Michelle

Michelle had not made a final decision regarding the undergraduate course for which she intended to apply for. However, she appeared to be certain about developing her undergraduate studies considering the programming skills that had been developed and/or improved during the Electro-electronics course. Moreover, Michelle appeared to have been influenced by the learning experiences with which she had been provided by the Electro-electronics course, since her career interest moved towards the technology field. Amongst others, the main reasons for that could be related to

Michelle's age (she was 19 years old) and the fact that she was near completing the last year of Secondary School. Thus, it can be suggested that Michelle was almost a certified technician who was about to enter the work market. Although Luisa and

Anne did not identify any choice actions, both of them had planned to take the national examination, ENEM, which could allow them to start the undergraduate courses within the technology field that they wanted.

This section has discussed the findings related to the Case Study 2 participants' choice goals towards the technology field. Findings revealed that the Electro-electronics course had influenced the participants' academic- and career-related goals. Self-efficacy beliefs and outcomes were found to be the factors which had impacted the most on the participants' choice goals. The next section addresses findings about the development of interests towards technology and other fields.

6.4.4. Within-case analysis of the development of interest towards technology

All the Case Study 2 participants claimed to have developed career interest stemming from their participation in the Electro-electronics course. Table 6.6 summarises the development of career interest according to the Case Study 2 participants.

Table 6.6: Case Study 2 participants' development of career interest

Participants	Career Interest related to Technology	Career Interest unrelated to Technology
Amelia	-	X
Andrea	X	-
Anne	X	-
Ethelyna	X	-
Luisa	X	X
Michelle	X	-

Michelle, Anne, Ethelyna and Luisa, who had identified choice goals related to technology, stated to have developed career interests towards technology. Those findings corroborated the argument that one's positive self-efficacy is related to one's outcome expectations after certain learning experiences (Brown, 2002). Andrea, who had chosen career-related goals within a different field, expressed career interest towards technology as follows:

They [teachers] really teach you well here [at the Centre] so I don't need to search for more information (...) only programming (...) I ask Michelle

to help me with programming because she knows more about it (...) I also have a computer at home, but I don't use it very much. I don't care for computers much (...) everybody asks me if I'm on Facebook and these kinds of things, but I'm not, I don't like it very much.

Andrea

Given that Andrea did not search for further information regarding the topics within the course curriculum, it can be argued that Andrea's interest was limited to the learning experiences provided by the course rather than expanded towards other technology-related subjects. Andrea seemed to have relied on Michelle during the tasks involving programming, which might have been influenced by and/or impacted on Michelle's positive self-efficacy beliefs and outcome expectations towards programming assignment. Andrea's interest towards technology might be ephemeral and motivated by her colleagues' contributions to and/or performances during the course.

Luisa, who claimed to have developed career interest towards technology-related and other fields, explained the reasons why she had to stop a research about programming as follows:

Programming was hard because computing language (...) everything's in English (...) sometimes, a bracket, a semicolon that is written on the wrong place and, then, nothing works. Sometimes, I don't have enough time to finish a code in class (...) I have to come back on the next day (...) start everything again.

Luisa

Luisa seemed to have developed an interest towards programming; however, Luisa did not have internet access at home and, therefore, could only programme in class [Researcher's field notes, CESMAR Centre, Electro-electronics Class]. Despite having to deal with that and other issues (further details in Section 6.2.1.6), Luisa appeared to understand the importance and complexity of being thorough during a task involving programming. The approach used by the teachers might have contributed to Luisa's understanding about the particularities of this language (e.g. the order of symbols to organise the commands that are sent to control boards, such as Arduino and Raspberry Pi). Nevertheless, the teachers might not have been able to provide Luisa with additional, yet relevant, resources which could have helped her to continue developing the research about programming.

Findings revealed that Ethelyna's, Anne's and Michelle's interests towards technology might have been related to their self-efficacy and outcome expectations beliefs which seemed to have motivated them to try new learning experiences. Such phenomenon is referred to by Brown (2002) as a loop of interest. The next extract summarises the participants' perspectives on the matter:

There was a software [3D Printer Cloner] that I downloaded recently, before the MOSTRATEC (...) I don't even like the software, but I downloaded it to use it with the 3D printer and everything. I drew several things and I enjoyed it very much (...) so I downloaded it to know more about it because we had had a very basic lesson about it (...) and the teacher had warned us that we could need it for our final project (...) I couldn't make it work well yet, but at least I've tried.

Ethelyna

Ethelyna seemed to have developed an interest in designing while working on the software for the 3D printer which was going to be used for her final project – the medicine dispenser. Anne, who worked on the same project with Ethelyna, developed an interest towards technology related to self-efficacy and outcome expectations beliefs. Anne claimed to have researched about relays after having a class about the topic. As previously mentioned, Anne was interested in Informatics hardware and Electronics, which might have been motivated by her successful participation in several learning experiences (such as projects and robotics competitions and classes) involving those areas. Anne could apply her skills related to Informatics and Robotics alongside her research about relays to two projects on which she worked with her teammates. It can be argued that Anne found new answers to the problems concerning the use of DC motors rather than using industrialised pre-conceived motor shields [Researcher's field notes, CESMAR Centre, Electro-electronics Class].

Michelle's interest towards programming languages, robotics and development software is an example of "loop of interests" which was stated as follows:

I looked for more information about drones and other things related to programming languages like HTML, Java, JavaScript, C++ (...) I also searched about AUTOCAD (...) something that you use in the Engineering courses. I learned about it here at CESMAR and I got interested.

Michelle

Michelle appeared to have expanded her knowledge about several topics which had been studied in class (such as programming, software development and robotics) by conducting further research outside the classroom. The quotation suggests that Michelle had constantly developed interest towards different subjects and their specificities. Michelle's apparent confidence in performing various tasks might have stemmed from the positive self-efficacy beliefs and outcome expectations which she had developed during the course.

This section has focused on the findings about the development of the Case Study 2 participants' interests towards technology and/or other fields. Findings revealed that Luisa and Andrea, despite having shown some interest towards technology-related careers during the course, were most likely to develop a career interest in other fields. However, Michelle, Anne and Ethelyna seemed to have sustained an interest in technology-related areas towards which they had developed positive self-efficacy beliefs and outcome expectations. Furthermore, those participants' choice goals and perceptions about their strengths, performance domains and attainments appeared to have influenced them to be involved in a "loop of interests" towards technology. The next section discusses the findings about the factors of support which might impact on the development of the Case Study 2 participants' career interest.

6.4.5. Within-case analysis of factors of support

The contextual influences which might support the development of one's career interest towards technology were important for this study because of the participants' socio-cultural and economic circumstances. Interview data indicated the importance of three key factors – opportunities for skill, range of potential academic career role models and emotional and financial support. Table 6.7 presents the Case Study 2 participants' perspectives concerning the influence of those contextual factors on the development of their career interest.

Table 6.7: Supporting factors identified by the Case Study 2 participants

Participants	Opportunities for skills	Range of potential academic career role models	Proximal influences (emotional and financial support)
Amelia	X	-	X
Andrea	X	-	X
Anne	X	X	X
Ethelyna	X	X	X
Luisa	X	-	X
Michelle	-	X	X

Five of the six participants identified opportunities for skill as a factor which can play a major role on the development of career interest. According to Lent et al. (2002), supporting factors can act as a moderator effect strengthening or weakening the relationship between variables. For example, CESMAR Centre is the only educational setting providing free technology-related courses for large economically disadvantaged and/or socially-marginalised communities within the north area of Porto Alegre. The variety of learning experiences which are provided by the courses offered at the centre should be enough to engage the participants who, in turn, might develop different self-efficacy beliefs and outcome expectations regarding their skills. The next extracts present Amelia's and Ethelyna's perceptions on the matter in order to exemplify such process.

They [courses at CESMAR] provided us with electronics, software, English and communication lessons (...) we have so many opportunities to grow here (...) here you find all the support you need (...) despite the rules...I think the rules are good, sometimes...you become a better person.

Amelia

I came here to attend the CRC and I did not have any idea when the course would start (...) they told me that the courses accept people according to their ages. I was 17-18. I was the youngest student (...) I would learn so many things (...) It's good for me (...) it's different.

Ethelyna

Both participants emphasised the advantages of the Centre and the diverse learning opportunities that the courses provide. The accounts suggest that well-trained professionals offer guidance and support to those attending, and/or are interested in attending courses at the Centre. Moreover, assorted disciplines – such as electronics

and English – seemed to be taught alongside classes (e.g. communication) which focused on personal development.

The range of potential academic career role models is a contextual factor that can support one's career interest, according to Michelle, Anne and Ethelyna. The extract below summarises the role played by such factor during the course according to Ethelyna.

I am not used to talk to the team coaches from other institutions outside CESMAR. I think I only talk to the ones from here, the educators here (...) there are professionals who study and work within many areas around here too.

Ethelyna

When asked about career role models and their view on the work market, the Case Study 2 participants could not identify all the factors and role models to which they had had access [Researcher's field notes, CESMAR Centre, Electro-Electronics Class]. However, Anne, Ethelyna and Michelle claimed that the courses and/or classes offered within CESMAR had provided them with access to a large range of professionals working in different technology-related areas [Researcher's field notes, CESMAR Centre, Electro-Electronics Class]. Ethelyna's account emphasises the importance of the over 30 educators who work at the Centre. Those experts had been responsible for teaching a range of classes and curriculum topics (e.g. Pedagogy, technology-related subjects, such as network, electronics, engineering, automation, mechanics, software engineering, robotics, Informatics) [Researcher's field notes, CESMAR Centre, Electro-Electronics Class].

Proximal influences, which are related to emotional and financial support, were identified as a supporting contextual factor by all the participants. Such support was claimed to have stemmed mainly from the participants' families and/or partners. The quotations below reflect the participants' opinion about the matter.

She [her mother] makes lunch (...) I come back home tired and I'd say something like "I'm going to skip class tomorrow" and she says "No, you're not, you're almost finishing the course. Just a little bit longer!".

Ethelyna

They [her parents] think this is cool. They really like what I do. They even ask me if I'm going to continue doing this because it's so different than most of what people do.

Amelia

My father passed away (...) I only have her [her mother]. She's always saying: "you must study because the studies are the base of everything in life" (...) she's always talking to me, advising me.

Anne

The participants identified their families as their main source of support to continue attending the course; moreover, the quotations suggest that the participants' mothers advised them and encouraged them to take the course seriously. Findings indicated that the Case Study 2 participants' parents did not seem to pressure them to find a job immediately; conversely, their parents appeared to have advised them to continue their studies in order to pursue a career in the future. Luisa exemplified her partner's support as follows:

My partner says that I have to continue in this field because I have to earn more money (...) I'll get there, but I've already told him that I don't know (...) maybe, if I had an opportunity I'd certainly work within this field, but this is not my dream (...) if I have to work within this field to achieve my dream, I will (...) he always encourages me: "go to class, don't give up, don't skip it" (...) in almost two years, I only missed two classes.

Luisa

Luisa's partner seemed to encourage her to continue studying in order to be more qualified and have more options within the work market. Luisa's partner's support appeared to have influenced her choice goals, since she claimed to have dreamed about working within a field which was not related to technology. Amelia's partner's and parents' support, however, was not enough to influence her choice goals towards technology, as the following extract suggests:

We [Amelia and her partner] moved to another town recently (...) before that, we used to live near here [CESMAR] (...) then, he got a new job in this other town, but I stay here during the week at my mother's.

Amelia

For Amelia, attending the course meant to travel, at least, twice a week, since she lived in another city with her partner. Andrea had the same issue. Both Amelia's and Andrea's parents supported them financially and let them stay with them during the weekdays so that they would be near CESMAR. Michelle also emphasised her

mother's and sister's financial support, since, thanks to her mother, Michelle could stop working and go back to school to conclude her Secondary studies. Michelle claimed that her mother matriculated her at CESMAR without her knowledge after having noticed Michelle's potential in Informatics. According to Michelle, her mother wanted her to achieve goals which the women in their family had never had the opportunity to achieve [Interview, CESMAR Centre, Electro-electronics Class]. It can be argued that family support had impacted the development of Michelle's career interest towards technology.

The next section focuses on the factors that act as barriers for the development of one's career interest towards technology.

6.4.6. Within-case analysis of factors of barriers for the Electro-Electronics class

Considering the SCCT theory, the factors identified as barriers by the students attending the Electro-electronics course at CESMAR were divided into three categories:

- (1) distal contextual influences, comprising cultural and gender roles;
- (2) proximal influences, representing socio-structural barriers; and
- (3) person inputs, involving disabilities, health status, predispositions, gender and ethnicity.

Table 6.8 presents the factors of barriers which were identified by the Case Study 2 participants.

Table 6.8: Factors of barriers identified by the Case Study 2 participants

Participants	Distal Contextual Influences	Proximal Influences	Person Inputs
Amelia	X	-	-
Andrea	X	X	-
Anne	X	-	-
Ethelyna	-	X	-
Luisa	X	X	-
Michelle	-	X	X

Cultural and gender roles, which are related to distal contextual influences, were identified by four of the six students as factors of barriers that might impact the development of their career interest towards technology. Amelia, Andrea and Anne identified issues regarding the acceptance of female professionals in the technology field whereas Luisa identified both cultural and gender issues within the student-teacher interactions. Luisa explained her perspectives as follows:

I think the teachers lack sensitivity (...) men talk harshly, women, don't. (...) sometimes, teachers aren't feeling ok and start their classes being rude (...) the communication problems between us [students] and them [teachers] start right away (...) but time balances the situation (...) the teachers can be flexible, so they accept it quite well when we tell them things like "I didn't understand that" or when we make a mistake or we say we're sorry (...) that's why our relationship isn't too bad.

Luisa

Luisa seemed to have identified the necessity to have a balance within the male teachers-female students' relationship. Given that the students attending that Electro-electronic course were all female, Luisa believed that the male teachers might have lacked the social and/or communication skills to understand the emotional and professional characteristics of those students. Luisa claimed to have felt that all females in the group could be seen as 'destined to fail' by the male teachers in the beginning of the course; however, she suggested that, with time, their relationship improved [Interview, CESMAR Centre, Electro-electronics Class]. For Amelia, the problem was related to the society's perception about the role that women should/could play within their community, as the extract below exemplifies.

People think I am incredible (...) because they can't believe that I do what I do, not even my boyfriend believes (...) once, were assembling a new table we had bought and we needed to screw the table at the wall (...) my boyfriend said "I'll not let you do it because you're going to hurt your fingers", but I did everything perfectly and he was like "Wow...well done!" (...) I've already done a lot of things at home, but he keeps looking at me with that astonished look on his face (...) most people think that just because you're a woman you can't do things like that.

Amelia

Amelia used her partner's sexist perception regarding the roles that women are expected to play within the household as an example of how society, according to

her, sees women. Considering that Amelia herself claimed that, when there were male students attending the course, the female students would wait for help with certain tasks (e.g. programming), it can be argued that Amelia's attitude concerning women's roles changed during the course [Interview, CESMAR Centre, Electro-electronics Class]. The fact that the female students were encouraged to play various roles to develop the tasks within the course programme – especially after the male students stopped attending the classes – might have influenced Amelia's views on women's roles at both levels, professional and personal. Andrea and Anne claimed that, in order to be accepted within the technology field, they would have to overcome a strong gender prejudice, as the extracts below suggest.

It must be difficult being a woman and working with electronics (...) men might not like it (...) I think there is some prejudice against women.

Andrea

In the beginning of the course, I thought everything was so odd. We, women, dealing with those "men things", like, disassembling parts and that kind of stuff, using screwdrivers, using machines, but, now, I think everything is normal (...) it feels good to be unique and, in this field, we are (...) we, women are more dedicated (...) men, sometimes, give up so easily, but not us.

Anne

Andrea and Anne highlighted the necessity to overcome the gender barrier within the technology-related field. Andrea seemed to believe that women will always suffer with prejudice whereas Anne's account was more optimistic, since Anne believed that women's dedication and persistence might enable them to overcome gender-related barriers.

Socio-structural factors of barriers, which are related to proximal influences, were also identified by four of the six Case Study 2 participants. As examples of those factors, the students mentioned three key issues: (1) the amount paid by CESMAR to the students under a scholarship; (2) lack of financial support from their families; and (3) the long time that takes for CESMAR to purchase necessary equipment. Andrea and Luisa emphasised that the monthly payment of R\$ 394.00 (approximately £85.00) received by the students through PJA was too low (the amount represented half the Brazilian minimum wage). Despite being enough to cover the students' material fees and some other additional expenses (e.g.

transportation), the students tended to use the money to help with their household budget due to the socio-economic context in which most of them lived. The need to contribute with the family income was the main reason why the students left the course and/or presented poor attendance between the period of 2014 and 2016. Andrea's and Luisa's quotations, below, exemplify the significance of those barriers.

One of our former [male] colleagues said that what we earned here wasn't enough and he wanted to leave (...) we used to have another [male] colleague whose girlfriend was pregnant, so he said that he was making too little money.

Andrea

The Centre helps me not only in terms of knowledge but also with money, since I use the money to pay the mortgage (...) I bought a house (...) all my money is used to pay my mortgage (...) but it makes me happy (...) I'm a very determined person.

Luisa

Both Andrea and Luisa referred to the salaries that students earned at the Centre through PJA. Andrea seemed to have a pessimistic view regarding the scholarship, since she claimed that the salary was not enough to some of her colleagues who had to leave the course. Luisa, in turn, stated that her entire salary was used to pay her mortgage. Because she appeared to need that money to help with the payments of her house, Luisa might have felt extra pressure to do well – especially in terms of attendance – in order to keep her scholarship. The lack of a computer at home was another socio-structural barrier mentioned by Luisa which might have influenced her performance within the course. According to Luisa, she could not download the software to practice at home what she had learned in class; however, Luisa claimed that she used to think about strategies to solve the problems and perform the tasks [Interview, CESMAR Centre, Electro-electronics Class]. Luisa seemed interested in learning more about the topics studied in class, but the fact that she did not have a computer at home might have become a barrier in her learning path towards the technology field.

Socio-structural barriers also seemed to have influenced the development of Michelle's interest towards the technology field. Michelle claimed that if she got a college scholarship, it would be great in terms of having the opportunity to focus on her studies; however, she would not be able to help her mother financially [Interview, CESMAR Centre, Electro-electronics Class]. The fact that Michelle's family appeared

to struggle financially was identified as a barrier which might influence the development of her career interest.

Another socio-structural barrier that Michelle and Ethelyna identified as an influential factor was the delay of CESMAR in purchasing equipment/electronics components which were not available to the students at the recycle station. The following extract presents Michelle's opinion on the matter:

I think that it takes too much time for the resources to arrive here [at the Centre] (...) sometimes, we need a robotics piece and it takes days for them to buy it, or for them to have the money to do it.

Michelle

According to Michelle, the Centre appeared to have an issue regarding the purchase of certain materials and/or equipment which were perceived to be necessary by the students. There was a management department at CESMAR, and it was their responsibility to deal with any purchasing-related requirements; however, the students' complaints about the delays seemed to have been a recurring issue throughout the course. Findings revealed that such situation had been frustrating the students, especially Michelle and Ethelyna, whose robot, which was completed with pieces that had arrived only a week before the MOSTRATEC, malfunctioned during the event.

Person inputs, such as health status, gender, disabilities, were identified by Michelle as a factor of barrier that might influence the development of career interest towards technology. Michelle exemplified her views as follows:

I have a problem because my mum is quite anxious, and she has a medical condition (...) she has to take medication (...) and it's kind of "family thing" (...) I have a condition (...) my hand begins to shiver when I'm anxious, nervous and I wonder "How am I supposed to perform a surgery with a shivering hand?" It is not possible (...) That's why I started to consider other possibilities (...) I could be a GP, but not a surgeon (...) but, then, I learned that I could something else, something that I really enjoy doing and that I can do it.

Michelle

Michelle explained that a pre-existent health condition had influenced her interests and choice goals towards a career – Michelle claimed that she wanted to be a

surgeon but had changed her mind because of her condition. Michelle appeared to have found and focused on her strengths which might have enabled her to develop career interest towards the technology field. The next section discusses exactly that: the development of career interest towards technology.

6.4.7. Within-case analysis of the development of career consideration towards technology

This section examines the development of the Case Study 2 participants' career consideration towards technology. It reviews their statements regarding previous interests (both related and unrelated to the technology field) and compares those initial interests to those developed during and/or after the participation in the Electro-electronics course. Table 6.9 summarises the findings about the participants' career interests.

Table 6.9: Case Study 2 participants' career interests and considerations

Participants	Previous interest unrelated to the technology field	Previous interest related to the technology field	Career consideration unrelated to the technology field	Career consideration related to the technology field
Amelia	Physical Education	-	Physical Education	-
Andrea	Physical Education	-	Physical Education	-
Anne	Veterinary Physician	-	Veterinary Physician	Electronics Engineer
Ethelyna	Pedagogy	-	Pedagogy	Engineer, Computer Science, Technician
Luisa	Pedagogy	-	Pedagogy	Informatics Teacher, Technology Supervisor
Michelle	Medicine	Computer Engineer	-	Automation Engineer, Computer Scientist

Findings revealed that most of the participants were still interested in careers unrelated to technology. Nevertheless, interest towards the technology-related careers was developed, to a certain extent, by most of those who had not expressed interest before starting the Electro-electronics course. The information presented in Table 6.7 can be divided into three contexts:

- (1) Amelia and Andrea's career interest were unrelated to the technology field both before and after having attended the course at CESMAR;

(2) Anne, Ethelyna and Luisa's career interest were unrelated to the technology field before and after having attended the course at CESMAR; however, the three participants developed interest towards technology-related career; and

(3) Michelle's career interest was related to technology both before and after having attended the course at CESMAR.

Despite having developed career interest in a field other than technology-related, Luisa, Anne and Ethelyna claimed that, if they had to choose an undergraduate course to start at that moment, they would probably prefer a technology-related major. In the extract below, Ethelyna clarified her preferences.

If I had the opportunity to choose one of them [Pedagogy, Computer Science and Engineering], I would pick between Computer Science or one of the Engineering Courses.

Ethelyna

Findings indicated that Ethelyna, as well as Anne and Luisa, had changed their perceptions regarding their skills and, therefore, it can be argued that such new perspectives might have contributed to their decision of moving their career interest towards the technology field. This argument can be supported by their claims concerning their self-efficacy and outcome expectations beliefs – especially within areas such as Electronics Engineer (Anne), Engineering/Computer Science (Ethelyna) and Informatics (Luisa).

Michele, who claimed to have developed career interest towards the technology field before attending the course at CESMAR, developed an interest in Informatics and Engineering. Interview data revealed that, by the end of the Electro-electronics Course, the learning experiences to which Michelle had accessed motivated her to research about specificities of undergraduate courses related to Engineering and led her to develop career interest towards Computer Science. Michelle's decision might be related to her remarkably positive outcomes during the course within Informatics-related topics (e.g. programming) and slightly negative outcomes within Engineering-related areas.

Amelia and Andrea claimed that their participation in the course had not influenced the development of their career interest – which was related to Physical Education.

Despite having developed positive self-efficacy and outcome expectations towards electronics, it seemed that such achievements were not enough to motivate those students to consider a technology-related career, as the following quotation suggests.

I liked this course [Electro-electronics] because I attend it here [at the Centre] (...) I know a lot of people (...) I'm going to be a Physical Educator because I like sports a lot. I like to play football, volleyball...

Andrea

I prefer Physical Education! I also like the idea of going to Nursing School. If I could study both, that would be brilliant but if I want to study Physical Education first.

Amelia

Both participants confirmed, after having attended the course, their career interest towards Physical Education – a field which is unrelated to the technology field. It seemed that, instead of encouraging Amelia and Andrea to move their interest towards the technology-related field, their participation in the course helped them to confirm their career interest in Physical Education. Although, as it has previously been mentioned, the development of skills stemming from the participation in technology-related courses can influence the acknowledgement of positive self-efficacy and outcome expectations, the development of interest and/or consideration towards a technology-related career might not occur. The next section presents the findings about the relationship between the development of confidence towards technology and the participation in the Electro-electronics Course.

6.4.8. Within-case analysis of the development of confidence towards technology

The Case Study 2 participants' opinions about their beliefs regarding their confidence towards technology enabled the understanding of which factors helped the development of such confidence. All the participants, as presented in Table 6.10, acknowledged that their confidence towards technology improved and/or was developed by the end of the Electro-electronics course, despite the relationship between the course and the development of their career interest.

Table 6.10: Case Study 2 participants' development of confidence towards technology

Confidence towards technology	Unchanged / changed negatively	Changed positively
Amelia	-	X
Andrea	-	X
Anne	-	X
Ethelyna	-	X
Luisa	-	X
Michelle	-	X

Anne, Ethelyna, Luisa and Michelle claimed that their understanding and knowledge about technology was a key factor which contributed to change their confidence level towards technology. The extracts below present Luisa's and Anne's opinions about the matter:

I feel way more confident because we've been learning how to assemble, disassemble a computer, programming it, installing software (...) it causes much trouble that you really learn about it and you get more confident about everything. Even a simple electric wire...before the course I'd look at a computer and the wires behind its monitor and I couldn't even touch it.

Luisa

In the beginning of the course, I didn't know anything about things related to components and computers, but, now, I'd say I have a good knowledge background about those things.

Anne

Anne's and Luisa's revealed that what they had learned during the course impacted their perceptions about their confidence towards technology. In this sense, the range of learning experiences with which those students had been provided (e.g. Electronics, Programming, hands-on activities with robots, robot designing) seemed to have played an important role in the development of their confidence. The participants seemed to have noticed their evolution from the beginning – when they felt that they could not perform simple tasks – to the end of the course – when they realised that they were able to develop complex tasks. Amongst many factors which

contributed to the development of the participants' confidence towards technology, Andrea and Amelia provided the following examples:

Before the course I really didn't know anything or knew too little about stuff like that (...) they have taught me so many things...taught us and, now, I know so much.

Andrea

In the beginning of the course I was "softer" and kind of lazy (...) I was asked to take this course (...) they called me at home and invited me to attend the course. That's why, in the beginning, I was kind of lazy (...) I didn't know anything, I didn't want to learn anything (...) I wanted to sleep.

Amelia

Andrea's comprehensive knowledge about the technology topics learned during the course seemed to have played an important role in the development of her confidence towards technology. Amelia, in turn, described a personal change in terms of behaviour. It can be argued that Andrea might have had a more passive attitude regarding her participation in the course, since she claimed that 'they taught' whereas Luisa, Ethelyna, Michelle and Anne claimed that 'they learned many things', which can represent a more active role towards their own learning process. Andrea identified external factors (e.g. teachers' work, need to learn the topics to continue in the course) to justify the development of her confidence towards technology. Amelia identified personal factors (e.g. overcoming laziness and need to behave properly as a student) to explain the development of her confidence towards technology.

The connection between the development of the participants' confidence towards technology and interest in a technology-related career varied. Confidence towards technology seemed to be stronger in those who had developed, to a certain extent, career interest towards technology (Michelle, Anne, Luisa and Ethelyna). Regardless, all the participants appeared to have identified the development of confidence towards technology as a positive factor.

6.5. Conclusion

This chapter has analysed the development of career interest towards technology based on the SCCT model (Lent et al., 1994). A framework informed by the SCCT

model of basic development of career interest considered factors, such as self-efficacy, outcome expectations, interest, goals, to investigate the participants' career interest development. Factors of barriers and supports and confidence towards technology were also analysed to establish their potential impact in the development of those participants' career interest.

Findings indicate that Michelle, Anne, Ethelyna and Luisa were able to develop interest towards technology careers after a period of more than 18 months during which they attended the Electro-electronics course at CESMAR. Andrea and Amelia, in turn, were not able to identify interest towards technology careers while this study was being conducted. Michelle identified interest in technology careers before having started attending the course. Anne, Ethelyna and Luisa, who had identified interest towards fields unrelated to technology (Physician, Pedagogy and Pedagogy, respectively), claimed to have considered a career within the technology field after the course. Their previous interests were not dismissed completely though; however, they did not seem to have remained as their first option. Andrea and Amelia did not express any desire to pursue a technology-related career and their previous career interest in Physical Education remained unchanged after having attended the course. Possible reasons why Andrea and Amelia attended the course until completion, even though they appeared to have no interest in a technology-related career, are explored in Chapter 8.

Findings indicated a connection between self-efficacy and outcome expectations and the development of interest towards technology careers (e.g. Bandura, 1994; Lent et al., 1994; Vondracek et al., 2014). For example, Michelle seemed to have changed her career consideration from Informatics and Engineering to Computer Science due to her positive self-efficacy in programming. Participants such as Anne, Ethelyna and Luisa, who developed positive self-efficacy beliefs towards Informatics, Robotics or Electronics, changed their career consideration towards, respectively, Electronics Engineering, Engineering and Informatics.

Table 6.11 presents a summary of the findings regarding the Case Study 2. The table highlights if the participants could perceive themselves to have developed interest towards technology careers and sustained such interest in order to achieve goals, interests, career consideration and a broader view of the labour market. Table 6.11 was developed according to the SCCT model of basic development of career interest,

taking into account factors of barriers and supports which could influence such development towards technology careers. Negative perceptions or identification of interests/goals towards fields unrelated to technology were underlined.

Table 6.11: Summary of the findings regarding the Case Study 2

Participants	Amelia	Andrea	Anne	Ethelyna	Luisa	Michelle
Self-efficacy	*Robotics *Electronics <u>*Programming</u>	*Electronics *Engineering skills <u>*Programming</u>	*Informatics *Electronics *Engineering skills *Robotics	*Informatics *Electronics *Engineering skills <u>*Programming</u>	*Informatics *Electronics *Robotics *Engineering skills <u>*Programming</u>	*Informatics *Robotics *Electronics *Programming <u>*Engineering skills</u>
Outcome expectations	*Teachers' / colleagues' appraisal; *Successful performance in classes, projects and competitions	*Teachers' / colleagues' appraisal; *Successful performance in classes, projects and competitions	*Teachers' / colleagues' appraisal; *Successful performance in classes, projects and competitions	*Teachers' / colleagues' appraisal; *Successful performance in classes, projects and competitions	*Teachers' / colleagues' appraisal; *Successful performance in classes, projects and competitions	*Teachers' / colleagues' appraisal; *Successful performance in classes, projects and competitions; *Success in the area of programming
Interests	<u>*No interest towards technology</u>	*Engineering *Programming	*Electronics: components; *Informatics: hardware	*Robotics Challenges	*Programming *Professional Skills	* HTML, Java, JavaScript, C++; * Autocad; * Computer Science
Goals	<u>*Applying for a vacancy within the Physical Education School</u>	<u>*Applying for a vacancy within the Physical Education School</u>	*Work in an electronics company; *Apply for an UG course related to technology	*Supervise a robotics challenge next year; *Become an advisor *Volunteer at the CESMAR Centre	<u>*Applying for a public job unrelated to technology</u> ; *Applying for a job related to electronics to pay for an UG Course (undefined field)	* Technology mentor /volunteer; * Supervise a robotics challenge; * Applying for a vacancy within the Computer Science School; * Work in a company related to the technology field
Career consideration	<u>*Physical Educator</u>	<u>*Physical Educator</u>	*Electronics Engineer; <u>*Veterinary Physician</u>	*Pedagogy; *Engineer	*Pedagogy; *Informatics Teacher / Technology Advisor	*Computer Science
Broader view of labour market	*Limited contact with professionals from the technology field during the course	*Limited contact with professionals from the technology field during the course	*Broad contact with professionals within the technology field	*Broad contact with professionals within the technology field	*Broad contact with professionals within the technology field	*Broad contact with professionals within the technology field
Barriers	*Had to overcome personal learning issues	*Low salary paid through PJA	*Overcoming issues related to gender	*Lack of handouts related to programming; *Limited access to internet for solving issues related to programming	*Interaction with teachers; *Low salary paid through PJA; *Lack of technology equipment and access to information at home *Being her sister's legal guardian	* Lack of financial support; *Need to contribute to the family budget; *Suffers from anxiety
Supports	*CESMAR; *Financial / emotional support from family; *Has access to technology and information at home	*CESMAR; *Has access to technology and information at home; *Teachers' support (role models); *Emotional support from her partner	*CESMAR; *Teachers' support (role models); *Family provides financial and emotional support	*Family provides financial and emotional support	*CESMAR; *Teachers' support (role models); *Husband provides emotional support	*Family provides emotional support

CHAPTER 7 FINDINGS – PART III

7.1. Introduction

This section reports the findings of the Case Study 3 regarding the development of career interest towards technology, as Case Studies 1 and 2, according to the Lent et al.'s (2002) SCCT framework. The first third of the section focuses on the preferred ER approach used within the context where Case Study 3 was undertaken. The second third discusses factors involving self-efficacy, outcome expectations, choice goals, supporting and barriers in terms of their relationship with the development of interest towards technology in the Case Study 3 participants. Finally, initial conclusions concerning the findings about the Case Study 3 are presented.

7.2. Case Study 3: EMEF José Mariano Beck - robotics as a full-time schooling activity

From 2007 to 2016, the City Council of Porto Alegre developed the implementation of ER as a tool for learning throughout their education system. The original idea was to provide teachers/pedagogical teams with continuing development in ER in order to implement interdisciplinary projects which would use robotics throughout the curriculum. However, because of issues such as the lack of human resources and basic infrastructure within the schools, 26 of 54 primary schools which are municipally-funded continued to implement the new educational technology until 2013 [Interview with Educational Robotics Program Coordinator, Porto Alegre City Council, 2015]. In 2015, when the fieldwork for this study was undertaken, the robotics-based activities were being developed in only 21 schools. Some schools would offer ER exclusive as an afterschool activity as part of the implementation of full-time schooling; however, most of the schools offered ER approaches as supplementary activities within PME, amongst which was Escola Municipal de Ensino Fundamental (EMEF) José Mariano Beck.

EMEF José Mariano Beck is in the Jardim Carvalho District – which is an economically-challenged area within the outskirts of Porto Alegre. The school is attended mostly by members of a culturally diverse community and has been providing important afterschool activities for over 100 of their primary students. In

2015, 585 students were attending classes at EMEF José Mariano Beck, 378 students belonged to the initial years (1st to 5th grades) and 207 students belonged to the final years (6th to 9th grades)¹¹. Two aspects can be highlighted regarding the school's infrastructure: (1) the availability of an Integration and Resources Room (SIR – Sala de Integração e Recursos), where, since 1985, pupils with special educational needs are tutored; and (2) the availability of afterschool activities through educational projects which were developed through seven outstanding and effective partnerships within the school community. Table 7.1 below highlights some demographic details about this case study's participants.

Table 7.1 – Demographic details about case study 3 participants

Educational Settings	Students	Gender	Age	Level of Education
EMEF José Mariano Beck	Andrew	Male	14	9 th grade/Primary School
	Peter	Male	12	7 th grade/Primary School
	Severus	Male	11	6 th grade
	Sheila	Female	11	6 th grade
	Daniel	Male	12	7 th grade/Primary School
	Donna	Female	13	7 th grade/Primary School

Data was gathered for the investigation in this educational setting as described in the table below:

Table 7.2 – Data Collection Timeline

Activity	2014			2015												2016											
	Oct	Nov	Dec	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Pilot Study online interviews (from 17/10/2014 to 30/06/2015)																											
Monthly reports from teacher (from 01/10/2015 to 29/04/2016)																											
Participants' online journals (from 01/10/2015 to 29/04/2016)																											
Participant observations (from 26/10/2015 to 13/11/2015)																											
Researcher's field notes (from 26/10/2015 to 13/11/2015)																											
Monthly individual's interviews with participants (from 01/12/2015 to 29/04/2016)																											
Monthly follow-up interviews with teachers and tutors (from 01/12/2015 to 29/04/2016)																											
Focus group interviews during fieldwork (from 26/10/2015 to 13/11/2015)																											
Analysis of documents from students (from 26/10/2015 to 29/04/2016)																											
Pilot study 2 online interviews (from 01/09/2015 to 30/09/2015)																											

¹¹ Census data related to the school was found at the http://www.qedu.org.br/escola/233022emef-jose-mariano-beck/censo-escolar?year=2015&dependence=0&localization=0&education_stage=0&item=, accessed on 01/12/2016. The page includes data regarding infrastructure, demographics, pedagogical goals and performance on the national evaluation examinations (e.g. Development Index for Basic Education, or Índice de Desenvolvimento da Educação Básica – IDEB).

The ER group, which has been co-ordinated by a faculty member, has also developed several partnerships, amongst which the following must be highlighted:

- (1) the Tennis Foundation Rotary Club which provides tennis workshops three times a week;
- (2) the Sport Club Internacional Education and Culture Foundation (FEI – Fundação de Educação e Cultura do Sport Club Internacional) which provides full-time schooling as well as in-service teacher education;
- (3) the Data Processing Company of Porto Alegre (PROCempa – Companhia de Processamento de Dados do Município de Porto Alegre) which provides internet connection and support regarding open-source technologies; and
- (4) the labour unions and foundations which are related to the State Electric Companies (CEEE – Companhia Estadual de Energia Elétrica) which have been funding projects that are developed by the school, such as field trips.

Their ER course, also known as “Equipe Legol”¹², started in 2007 as a result of the First Robotics Challenge (FRC). The schools which had been funded by the Porto Alegre City Council were invited officially to participate. Almost 30 schools participated in the FRC that year, including representatives from EMEF José Mariano Beck, such as the teacher who co-ordinated the ER project and the first group of ER students. After having spent months learning the Lego® methodology, ten students were invited to participate in the FRC which would occur that December. Despite being their first participation in the event, the students earned a place in the national stage of the competition. The successful outcome inspired the teacher/co-ordinator and other students to continue to develop the project and to organise a schedule so that they would be able to participate in other events.

Approximately at the same time, the Secretary of Education within the Porto Alegre City Council started to provide the schools which had been developing ER activities with support through the Advisory Service in ER, a sector of the Secretary that is specialised in digital inclusion. Until the end of 2016, the Advisory Service managed in-service teacher training courses in ER; the development of ER curriculum; and the organisation of a common calendar of ER-related events for those schools.

¹² The Equipe Legol's website can be visited at the <http://equipelegol.blogspot.com.br/> , accessed on 01/12/2016.

The EMEF José Mariano Beck ER group started with approximately ten students in 2007. The ER activities were offered on Mondays, Tuesdays, Wednesdays and Fridays from 13.30 to 17.30 and the group would rarely be comprised of more than fifteen students. However, in 2014, the City Council established a new requirement for the schools that participated in the full-time schooling initiative through PME: at least 150 students had to attend the workshops. At EMEF José Mariano Beck, it meant that 150 students would have to attend the ER activities alongside the ten-students group, “Equipe Legol”, who had been already participating in competitions, projects, etc. The new requirement was revoked in the following year, since schools such as EMEF José Mariano Beck could not provide an infrastructure which would allow more than ten students to develop ER activities.

Since 2010, all the group activities have been documented in their blog, which also presents the development of those activities and the rationale for the pedagogical choices regarding curriculum and equipment. While this study was being conducted (2014-2016), ER curriculum was considered to be activity-based because the ER experiences, such as competitions and projects, would define the participation of the team members and the topics to be learned for the current year. Interestingly, for the three years during which this educational setting was studied, their participation in events was fairly consistent and included the following:

- (1) one participation in the regional stages of the FRC;
- (2) one participation in the National Robotics Fair (MNR – Mostra Nacional de Robótica);
- (3) one participation in the International Science and Technology Fair (MOSTRATEC – Mostra Internacional de Ciência e Tecnologia;
- (4) one participation in the Marist’s Robotics Challenge;
- (5) multiple participations in several continuing education courses (such as opensource robotics kits, Lego® EV3 kit, 3D printers, Arduino, etc.);
- (6) one participation in the Porto Alegre City Council Robotics Challenge that was promoted by the Secretary of Education;
- (7) at least one participation in Science Fairs such as (a) the fair which was organised by the Porto Alegre City Council through the Secretary of Education; and (b) the fair that was promoted by the Federal University of Rio Grande do Sul;

- (8) one participation in the Brazilian Robotics Olympiad (OBR – Olimpíadas Brasileira de Robótica); and
- (9) one of the local robotics challenges that was promoted by other institutions (such as the University of Vale dos Sinos and the Military College of Porto Alegre).

According to the teacher, the first three months of the school year (February-May) were dedicated to “basic robotics training and teamwork training, as well as the development of the first stages of their MNR projects when there are students who were granted with MNR scholarships” [Interview with the teacher, EMEF José Mariano Beck]. Amongst the topics which are addressed with the students for the period that the teacher mentioned, the following must be highlighted:

- (a) basic robotics engineering with Lego® pieces;
- (b) programming with the block-based environment;
- (c) mentor-assisted development of robotics projects; and
- (d) rotation of the roles which have to be played within the projects (similar to what the Lego® methodology requires).

This initial period of the year is dedicated to the participation in ER classes and preparation for what can be called “robotics competition season”, which occurs between the months of May and December. The “robotics competition season” provides the students with many opportunities to participate in several of those challenges for which the students start to practice in February. Regional competitions (such as MOSTRATEC, OBR or the Marist’s Robotics Challenge) usually happen before November so that the students can have the month of November to focus on the preparation for the regional stage of FRC, which is held in December. In August, schools can submit the projects that started being developed in the beginning of the year by the students to be presented at the MNR, which is the greatest and most significant robotics event in Brazil.

They do not have a structured curriculum *per se*, although, throughout the year, they perform consistently all three ER approaches: ER classes, projects and competitions. That is why they can be considered to have a multi-ER approach curriculum, although an unstructured one. The ER approaches are developed each academic year and concomitantly as follows: (a) the classes season takes place from February to May; (b) the projects season occur from July to November; and (c) the competitions season

happen from May to December. The overlap of the projects and competitions seasons might affect the learning process since the workload with which the robotics teams need to deal is heavier. At times, the students would focus less on their robotics projects for the MNR in order to refine their robots for another competition, and vice-versa. If there is not a curriculum *per se* being developed at this educational setting, it seems fair to say that the body of knowledge to which the students have access through the ER approaches depend on the approaches themselves.

Data gathered for this study indicated that two pedagogical theories underpinned the development of ER activities in this setting: constructionism (Papert, 1981) and social constructivism (Vygotsky, 1978). In this environment, the teacher acts as a facilitator (Mubin et al., 2013), as it is common in ER activities. Particularly, group collaborative learning and guided discovery learning instructional strategies were adopted prevalently to be used for all the implemented ER approaches. Less frequently, traditional instruction and peer-assisted learning were also part of the array of instructional strategies performed at this ER setting. Further details provide an explanation for that.

Guided discovery learning is an instructional strategy greatly based on problem-solving and constructivism (Earle, 2011). Learners are invited to discover more about a study object through research, testing hypothesis or simply collecting data about a topic. Thus, the teacher's role, within this instructional strategy, is to facilitate the process of learning by giving feedback and/or guidance whenever the learners need it. It is not, however, an instructor-led type of strategy, since it is mostly led by learners (Schunk, 2012). This strategy was frequently used in two types of ER approaches: ER projects and ER challenges. For example, when learning about programming (one of the study topics that their teacher was not entirely aware of how to proceed in terms of teaching), learning would frequently happen through this approach. The same happened when they tested hypothesis regarding the reasons why the robot would behave differently depending on the possible variables used to programme movement (e.g. degrees, minutes, time) when using Lego Mindstorms kits.

Group collaborative learning was another instructional strategy that was characteristic of this ER setting. This kind of strategy involves two or more team members working together to understand a concept or to apply problem-solving. This knowledge is, then, brought to the group with whom they are working to be verified

and shared (Earle, 2011; Sullivan, 2011). This strategy was frequently used when learners were performing to complete ER projects, ER challenges, and even classes. For example, after having decided on the topic of an ER project, a group of learners would scaffold their knowledge construction to achieve their goals. Results would be, then, discussed within the group, who decided if they would accept that result, or expand their research to encompass more information about the studied topic.

According to the data gathered during the period of study, traditional instruction (Schunk, 2012) was rarely used in the ER setting and would be mainly reserved to the ER classes (in the beginning of each academic year). The same happened with peer-assisted learning. In this modality of instructional strategy, learners help other less-advanced learners to develop skills (such as technology skills) in a collaborative manner. Nevertheless, in the absence of someone who could check the precision of their information (such as a teacher expert in the development of technology skills), discovery learning was more frequently used than peer-assisted learning. Examples of peer-assisted learning found in this ER setting included all ER approaches; however, in a limited number of opportunities. Despite being able to rely on volunteers (tutors who had already graduated from Primary school), the fact that those tutors would be present less than once a month limited the opportunities for the students to practice this instructional modality.

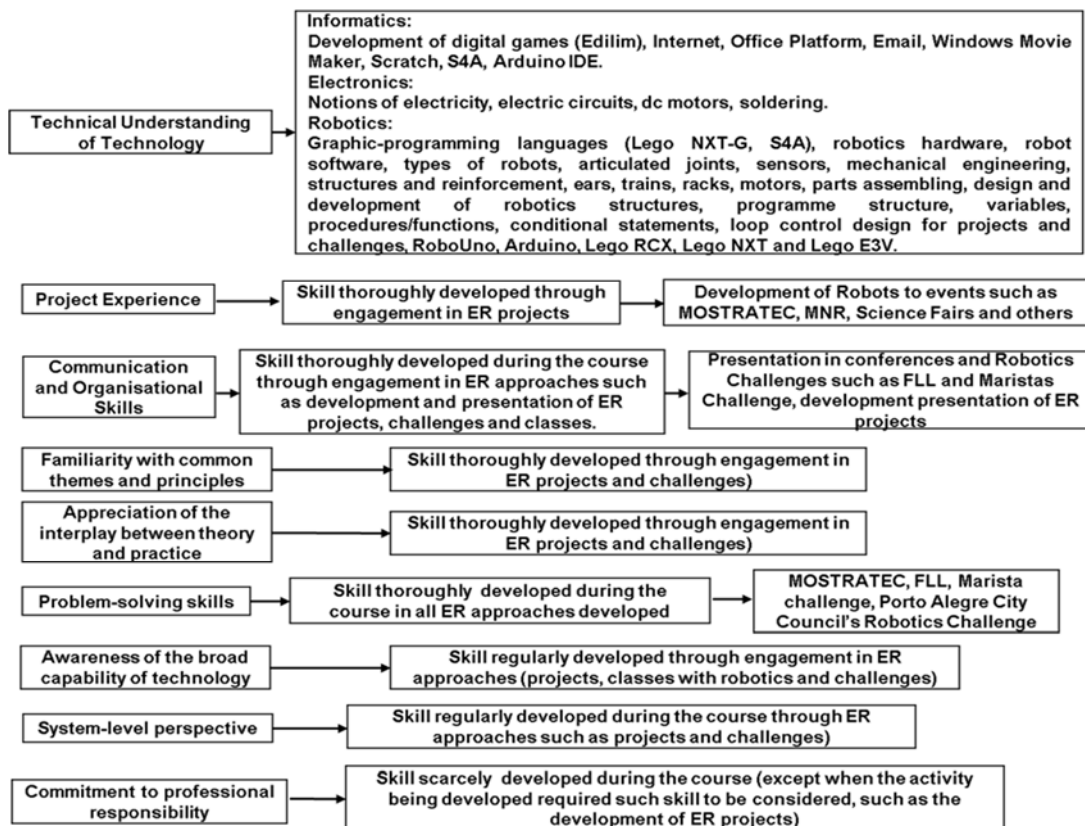
This section presented EMEF José Mariano Beck, one of the educational settings where this study took place, which has been implementing full-time schooling by providing afterschool activities, such as ER. It was highlighted that the school has been offering approximately 16 hours a week of ER activities for groups of 10 to 20 students. Other afterschool activities, such as pedagogical support and tennis, receive more than 100 students, which is more than half of the students who attend the final years of Primary School (6th to 9th grades).

At José Mariano Beck, the three ER approaches (competitions, projects and use of robotics as a tool in learning) have been used as part of their ER curriculum. The Case Study 3 participants were the six primary students attending classes at Beck School. The next section focuses on those students' developed skills.

7.3. Analysis of the development of technology skills in case study 3 participants

The Case Study 3 participants presented some differences regarding the development of technology skills in comparison to those participating in Case Studies 1 and 2. All the investigated educational settings focused on providing their students with multiple learning opportunities for skills development through different ER approaches. However, the course offered by the educational setting where this case study was undertaken was based on a curriculum which had not been informed by content; rather, the course seemed to be guided by the type of activity available at a determinate period of the year (see Chapter 3). In other words, the activities that had been proposed during the course informed the curriculum – which was the opposite case in the Case Studies 1 and 2 contexts, where there was a presence of a curriculum which privileged the development of technology skills. In this sense, the opportunities to develop technology skills depended largely on the types of activities proposed by the teachers. Figure 7.1 presents the technology skills which were developed by the Case Study 3 participants.

Figure 7.1: Technology skills developed by the Case Study 3 participants



Given the lack of a curriculum *per se*, if the Case Study 3 participants had been more involved with robotics challenges, for example, their chances to develop problem-solving and communication skills could have been higher. Within the context where the Case Study 3 took place, the following technology skills were developed thoroughly: (1) project experience; (2) communication and organisations skills; (3) familiarity with common themes and principles; (4) problem-solving; and (5) appreciation of the interplay between theory and practice. The technology skills related to awareness of the broad applicability of technology and system-level perspective were developed regularly within the ER group whereas commitment to professional responsibility was advanced scarcely. It is important to highlight that the technology skill involving commitment to professional responsibility was found to be less developed than the other skills in every educational setting where this study was undertaken.

The connections between the development of technology skills and the limited extent to which case study 3 participants developed interest towards technology careers are further explored in Chapter 8. The next section analyses the development of self-efficacy in case study 3 participants.

7.4. Analysis of development of career interest in technology in case study 3 participants

In the following sub-chapters, factors that influence the development of interest in technology careers according to the SCCT model (Lent et al., 2002) are analysed. In the final sub-chapter, the extent to which career interest was developed by each participant in case study 3 is examined, according to that model.

7.4.1. Within-case analysis of self-efficacy

The students at Beck School who participated in the ER group between 2014 and 2016 were provided with several learning experiences which might have influenced their self-efficacy beliefs. The key sources of self-efficacy identified by the Case Study 3 participants are detailed in Table 7.3.

Table 7.3: Sources of self-efficacy according to the Case Study 3 participants

Self-efficacy source	Personal Performance Accomplishment	Vicarious Learning	Physiological and Affective State
Andrew	*Development of (1) digital games; (2) robots; and (3) robotics projects *Informatics *Presentation	*Competition judges; *Older colleagues; *Other team members	<u>Nervousness</u> and Persistence
Daniel	Development of (1) robots; and (2) digital games	*Colleagues;	<u>Anxiety</u> and Happiness
Donna	*Development of digital games; *Presentation; *Robot programming; *Informatics	*Colleagues;	X
Peter	*Piloting *Programming; *Robot development *Presentation	*Colleagues; *Other team members	<u>Nervousness</u> and Persistence
Self-efficacy source	Personal Performance Accomplishment	Vicarious Learning	Physiological and Affective State
Severus	*Robot development; *Robot programming; *Research; *Presentation; *Team Work; *Informatics; <u>RCX Programming</u>	*Competition judges; *Other team members; *Colleagues;	<u>Nervousness;</u> <u>Anxiety;</u> Single-mindedness
Sheila	*Presentation; *Research; *Robot development; *Robot programming; *Development of <u>digital games</u>	*Colleagues;	<u>Anxiety</u> and Happiness

Personal performance accomplishments can be perceived differently depending on activities developed within a certain ER group. At Beck School, the three ER approaches – projects, competitions and use of ER as a tool in learning – had been constantly developed during the academic year. The students had been offered opportunities to learn and participate in learning experiences involving (1) the development of digital games online; (2) robotics projects (e.g. OBR and MNR); (3)

robotics competitions (e.g. regional and national stages of FLL, OBR, MOSTRATEC); and (4) Physics subjects (e.g. force, energy, power). Interview data revealed that personal performance accomplishment, as a source of self-efficacy, were identified by the students as positive, neutral or negative (underlined).

Andrew, Peter, Severus and Sheila seemed to have developed more positive self-efficacy beliefs towards their personal performance accomplishments than Daniel and Donna. As further discussed in Section 7.2.1.3, those four students were also those whose interest in technology-related careers had been more developed than the other two participants. The following extracts clarify the students' views on the matter:

When I started attending the ER classes (...) I firstly started working with the RCX (...) we participated in the OBR. When we went to the OBR, I had to learn how to programme the EV3, the NXT (...) mainly we used the NXT a lot (...) during my first FLL, in 2014, we started to use the EV3, and then I learned a lot about it (...) I felt that I wasn't that interested in developing robots (...) I was more interested in the research bit. I started to understand that it was much easier for me to do that.

Severus

I feel very proud of the digital games I developed in the Edilim platform (...) I developed ten games (...) I made the games for young school children to learn about recycling (...) I really liked the other games I developed too (...) the robot car I built and the robot dog.

Sheila

I developed the "Clean Game" last year for the young students and I could finish it (...) I made it from beginning to end and it was very difficult, but I did it!

Daniel

As suggested in the extracts, the three students mentioned learning experience-related accomplishments which might have influenced the development of positive self-efficacy beliefs. Severus seemed to have identified research and robot development as the areas towards which he had developed more and least interest, respectively; whereas Sheila, whose positive self-efficacy beliefs were mostly related to the development of digital games, appear to have developed interest in robot development. Despite having expressed little career interest in technology (see Section 7.2.1.6 for further details), Daniel's views on his personal performance

accomplishment might have contributed to his positive self-efficacy belief towards the development of digital games.

The second source of self-efficacy, which was mentioned by all the six students participating in the Case Study 3, was vicarious learning. Andrew, Peter and Severus identified multiple sources of vicarious learning whereas Daniel, Donna and Sheila mentioned only their colleagues. Findings evidenced that Andrew, Peter and Severus had been more autonomous than Daniel, Donna and Sheila regarding their participation in diverse learning experiences. Alongside the ER group mentors, Andrew, Peter and Severus established learning strategies (e.g. sharing experiences, consulting other ER groups' participants, teachers and event judges, and research) on which they could rely to develop their projects [Researcher's field notes, EMEF Jose Mariano Beck]. The next quotations exemplify those different attitudes towards vicarious learning:

We learned a lot about programming (...) a lot of things about calculation and degrees (...) we learned how to transfer, and, how to rely more on the sensors (...) we started to have better results, to learn more from other teams (...) like the Spartans (...) during the FLL, we shared a lot of information with the Team Androids (...) before the event, all I knew about programming the robot was how to make it move forward, backwards and side to side.

Severus

I learn from my colleagues (...) when I ask for help, they come and help me.

Sheila

According to Severus, members of other ER groups or teams, especially during robotics competitions (e.g. FLL), had been direct and/or indirect sources of learning. Moreover, Severus claimed that some discussions he had had with members of other teams had influenced him to become more interested in robots such as drones [Interview, EMEF Jose Mariano Beck]. Alongside Peter and Andrew, Severus was the participant who identified more sources of vicarious learning; those three participants, interestingly, were those whose interest in technology-related careers developed the most. Sheila, whose perspectives were shared by Daniel and Donna, seemed to have exclusively relied on her colleagues as a source of vicarious learning. Findings revealed that those three participants developed less interest in a career within the technology field than Andrew, Peter and Severus.

The third and last source of self-efficacy identified by all the participants, except Donna, was physiological and affective state. The five participants who mentioned such source claimed to have experienced similar negative feelings – nervousness and anxiety – and positive feelings – happiness and persistency – while trying to solve a robotics-related problem or developing a task. Observation data revealed that the five participants felt different levels of nervousness and anxiety during their performances. Andrew, Peter and Severus appeared to have felt nervous and/or anxious when a complex task was being performed; however, their persistency and single-mindedness would help them to focus on the task and overcome the negative feelings. Sheila and Daniel, whose positive feelings were more related to happiness, seemed to have perceived completion of tasks as an enjoyable activity rather than an accomplishment [Observations, EMEF Jose Mariano Beck].

Findings evidenced that the participants' perspectives might have been related to their age difference; Andrew, Peter and Severus were the oldest students whereas Daniel and Sheila were the youngest. Not only did their viewpoints differ but their roles within the ER group also seemed to be age/experience-based. Andrew was considered the official programmer of the main group, Peter was the pilot and Severus played the role as the leader engineer/researcher. Daniel and Sheila, in turn, helped Severus with research within the main group and played the role as engineers within the secondary group. [Observations, EMEF Jose Mariano Beck]. The extracts below present a summary of the pre/post-tasks emotional and physiological states identified by the participants.

For me, we succeeded during the regionals, but I got sick because of it (...) on the first day, I didn't want to have breakfast (...) five hours later, during lunch, I started feeling nauseous and I was sick (...) when I arrived home, I was still feeling a little sick and my head hurt (...) something similar happened during the nationals (...) I think it was more psychological than physiological.

Severus

I feel tense (...) nervous (...) mainly when we participate in competitions because we have limited time (...) there's a lot of pressure (...) the robot always works perfectly here in our classroom, but, when we participate in competitions, it starts bugging (...) it even seems that the robot's afraid instead of us (...) I'm always nervous about it (...) during the OBR, the robot was great here [at Beck] when we were practicing. As soon as we arrived there [at the competition site], it started malfunctioning (...) because I was the pilot, every time I had to reset it and restart it during the competition, I'd feel nervous.

Peter

I feel nervous because when I try to programme, and things don't work properly (...) if what I programme starts to act differently, I get pretty nervous and upset, and I ask my colleagues for help (...) when I succeed, I feel happy!

Sheila

Severus claimed to have felt stressed during ER competition events to a point that his mental status might have induced physiological reactions. Although Severus seemed to have had a positive attitude about such issue, he considered other ER approaches, such as ER projects, to be more suitable for him to develop his technology-related skills. Peter, whose perspectives echoed those of Andrew, identified the pressure of working within a time limit and of being a representative of the ER group. Observation and interview data revealed that the ER group at Beck School was able to focus on the preparation for the FLL competitions in which they participated. They would practice for more than 16 hours per week and Peter, who was the pilot, had the responsibility to co-ordinate the team, develop strategies for team programmers and engineers in order to decrease the time spent on performances and perform the task during competitions [Observations, EMEF Jose Mariano Beck].

The SCCT theory emphasises that physiological and emotional states might affect self-efficacy beliefs, both positively and/or negatively (Lent et al., 1994; Vondracek et al., 2014). In this sense, it can be argued that, despite having experienced negative feelings (e.g. stress, nervousness, anxiety), Andrew, Peter and Severus were able to develop positive self-efficacy beliefs towards their capacity to perform the tasks and participate in the competitions. Those participants seemed to have perceived those negative feelings part of their routine as robotics competitors. Sheila, in turn, did not appear to have perceived those negative feelings to be part of the task or to contribute to her performance. Conversely, Sheila claimed that she asked for help in order to solve problems and that her achievements made her feel happy. Sheila might have associated her accomplishments with happiness and her struggles with anxiety because she did not have to deal with the pressure of participating in a main team during a competition. Such attitude towards ER might change once Sheila moves forward to the second year within the ER group during which the ER-related tasks are more demanding.

The next section focuses on outcome expectations which, alongside self-efficacy beliefs, might influence career choice.

7.4.2. Within-case analysis of outcome expectations

According to the SCCT theory, outcome expectations might affect the development of one's career interest and choice goals (see Lent et al., 1989, 1994, 2002). The Case Study 3 participants' views on the sources of outcome expectations are summarised in Table 7.4.

Table 7.4: Sources of outcome expectations according to the Case Study 3 participants

Outcome Expectations	People's appraisal	Observation of the outcomes	Attention to self-generated outcomes	Sensitivity to physical cues
Andrew	X	X	X	X
Daniel	X	-	-	-
Donna	X	-	-	-
Peter	X	-	-	X
Severus	X	-	-	X
Sheila	X	-	-	-

Table 7.4 indicates that all six participants identified people's appraisal as a source of outcome expectations and three of those six mentioned sensitivity to physical cues (e.g. sense of well-being, emotional arousal). Andrew was the only participant who emphasised observation of the outcomes and attention to self-generated outcomes, alongside those two previously identified, as sources of outcome expectations.

All six participants claimed that having their performance praised by third parties was a source of outcome expectations. Interview and observation data revealed that such appraisals had not come from fellow students and/or teachers within Beck School; rather, those participants had been awarded prizes, certificates and medals due to their participation in ER-related events (e.g. MNR 2015, OBR, Nationals and Regionals FLL 2015) and had their efforts acknowledged by judges within robotics competitions (e.g. MOSTRATEC). It can be argued that the Case Study 3 participants had engaged in learning experiences which enabled them to develop the necessary skills to perform tasks within competitions successfully. Thus, the awards

and appraisals were perceived to be positive outcome expectations as the extract below suggests:

The FLL judges praised us a lot because of our project and we won the first prize for research (...) at the Nationals FLL, our teacher won the Best Coach Prize.

Severus

The awards and prizes seemed to have represented a recognition of the team's efforts in specific areas (e.g. development of robots, programming, communication) without, necessarily, influencing the participants' career interest towards technology. According to the students' teacher, the ER team raised awareness about recycling within an area where the City Council selective collection service was not available [Interview with the teacher, EMEF Jose Mariano Beck]. The competition judges had provided positive feedback regarding the project originality and problem-solving potential; moreover, they had praised the students' ability to present several actions to tackle the issue, such as the following:

- (1) online awareness through digital games;
- (2) a quantitative study showing the number of people in the community who had been recycling; and
- (3) children awareness through assorted games and playful actions with the Primary School students at Beck School [Documents, EMEF Jose Mariano Beck].

Andrew, who identified observation of the outcomes and attention to self-generated outcomes as sources of outcome expectations, explained his perspectives as follows:

We were awarded with the Best Research Prize and the Best Team Prize (...) they told me that I had done a great job with programming (...) I'd trained my speech to present to the judges at the FLL so many times that I didn't even need anyone's help with that anymore (...) when they started assessing us, and specifically me, I answered all their questions (...) they asked me things like: "what is this section of the code supposed to do"? and I said "This part is responsible for identifying the line, reading the black line so the robot can navigate".

Andrew

The quotation suggests that Andrew recognised that his programming skills had contributed to the team's high score and position at the regional stage of the FLL. Such recognition seemed to have impacted positively his self-efficacy and performance – which was praised by his colleagues and his coach [Interview, EMEF Jose Mariano Beck]. Andrew's awareness of his own skills and accomplishments might have enabled Andrew to develop positive outcome expectations beliefs, since Andrew's teachers and Andrew himself claimed that Andrew did not use to dedicate much time and effort on his communication skills before the FLL 2015 [Researcher's field notes, EMEF Jose Mariano Beck].

As physiological and affective states can be a source of self-efficacy, sensitivity to physical cues (e.g. emotional arousal and sense of well-being) might be a source of outcome expectations (Brown, 2002). Andrew, Peter and Severus, who identified this source, claimed to have developed sensitivity cues on several occasions while performing tasks as members of the ER group. The next quotations summarise those participants' perceptions while trying to solve a robotics-related problem:

At my first FLL, I thought that everything was calmer than the OBR event we'd been to. When we went to the FLL, though, everything had to be done quickly (...) you have to go to a certain spot and present something, and, after that, you have to do something else (...) on the next day, you go again (...) you feel really tired.

Severus

I used to get really shy when talking in front of others (...) now, I improved myself (...) I think I'm still developing my communication skills and I hope to continue developing them even more until the next opportunity.

Andrew

Severus, who had previously stated he had felt nervous/anxious while solving complex robotics problems, suggested that the time limit and the intensity within events such as FLL and OBR might be amongst the reasons why he presented negative feelings towards competitions. However, when developing ER projects, his preferred ER approach, Severus seemed to have felt more relaxed and prepared to develop his full potential [Researcher's field notes, EMEF Jose Mariano Beck]. Andrew, who claimed to prefer ER competitions, might have taken advantage of the preparation for the competition events to improve his performance. After having

participated in an ER competition, Andrew concluded that his communication skills had been improved.

It can be argued that, for students such as Andrew, Peter and Severus, the more pressure they felt the better they performed the tasks during ER competition events. Furthermore, the opportunity to participate in learning experiences provided within the Beck School ER group which simulate equally demanding problem-solving tasks, might have allowed the students to perform/rehearse and improve their skills for the competitions. Severus, Sheila, Donna and Daniel felt very nervous/anxious about their performances during ER competitions; however, they seemed much more relaxed/positive about their performances during ER projects at the school [Observations, EMEF Jose Mariano Beck]. ER competitions seemed to be suitable contexts for Andrew and Peter to develop their skills and improve their performances, even though both claimed to have felt nervous during competition events.

The next section discusses the findings regarding the development of the participants' interest towards technology-related careers.

7.4.3. Within-case analysis of the development of interest towards technology

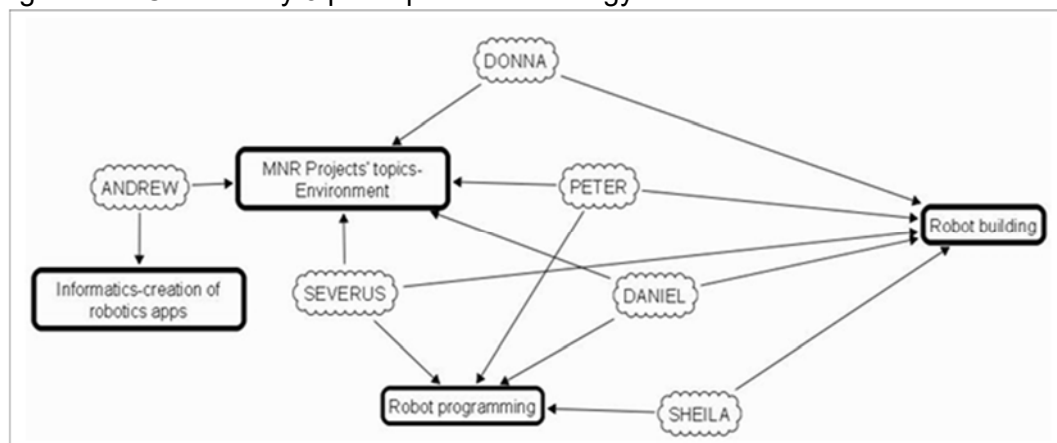
After having participated in ER learning experiences which might have enabled the development of positive self-efficacy and outcome expectation beliefs, the development of interest towards the technology field could be considered initial signs of career interest. All Case Study 3 participants claimed to have developed interest in technology-related careers – especially within the areas comprising the three ER approaches with which they had been working at Beck School. However, the six participants also claimed to have developed career interest towards fields that were unrelated to technology (see Table 7.5).

Table 7.5: Case Study 3 participants' development of career interest

Development of interest	Towards fields related to technology	Towards fields unrelated to technology
Andrew	X	X
Daniel	X	X
Donna	X	X
Peter	X	X
Severus	X	X
Sheila	X	X

Focusing on the different careers within the technology-related field, interview and observation data revealed that the participants' interests reflected mainly two key factors: (1) their preferred ER approach; and (2) what enabled them to develop positive self-efficacy and outcome expectations beliefs. Figure 7.2 summarises those findings.

Figure 7.2: Case Study 3 participants' technology-related areas of interest



As illustrated in Figure 7.2, five of the six participants expressed their interest in environment-related ER projects – which had been the topic of their MNR projects between 2014 and 2015. Robot building, which involved engineering skills and the use of ER kits (e.g. Lego® and Arduino), was also mentioned as an area of interest by five of the six participants. Robot programming, which had been done through graphical interfaces (such as NXT-G and Scratchduino), was selected by four participants whereas Informatics (especially the development of apps for robots) was only chosen by Andrew as an area of interest. The participants' perspectives can be summarised as follows:

I'd like to learn more about building robotic claws (...) accessories that I still don't know how they're made.

Sheila

Sometimes, I'd research about the FLL on YouTube at home, so I could see the best ways to create robot structures and types of actuators.

Peter

The project about recycling and the research about the robotics tournaments that I did were interesting for me.

Donna

I'd like to develop something related to Informatics (...) creating apps or something in that field (...) It's something that I experienced during the FLL and got me interested so I want to replicate it here [at Beck School].

Andrew

Given that the young students participating in the ER group, such as Sheila, do not have full access to the robotics kits as the older students, such as Peter, it is understandable that, despite their common interest, Sheila and Peter had experienced different stages and levels of complexity regarding robot building. However, the younger students might eventually replace the older students in their roles within the ER group at Beck School and, therefore, engage in more complex tasks and projects and become engineers/programmers to develop skills related to building/programming robot [Interview with the teacher, EMEF Jose Mariano Beck].

Donna, who claimed to have been mainly interested in solutions to real-life issues within her community (such as recycling), seemed to have had the development of her interest influenced by the flexibility and lack of a strict time limit that ER projects can provide. Interview data revealed that learning about a meaningful issue and being able to propose possible solutions through robotics/digital games impacted Donna, who created more than ten digital games to raise awareness about the environment and the importance of recycling [Interview, EMEF Jose Mariano Beck]. Andrew suggested that his interest in Informatics, especially in the development of applications for robots, had stemmed from his participation in the FLL/2016. This interest might have also been developed because of Andrew's role within the ER group at Beck School. Since Andrew was a senior, he had had many learning experiences involving robot building and programming; moreover, in the following year, Andrew would be back to the ER group as a mentor. Thus, his interest in complex tasks, such as applications development, might have been related to his positive self-efficacy beliefs towards Informatics and can enable him to pursue an Informatics-related career.

The next section addresses the Case Study 3 participants' choice goals and actions and how they are related or unrelated to the development of those students' interest in a career within the technology field.

7.4.4. Within-case analysis of the development of choice goals/actions

Given that the Case Study 3 participants were not Middle school students, having a career in mind and/or choosing an area to develop further studies might not have been an urgent issue for most of them. In this sense, their perspectives regarding choice goals and actions were related to next steps within the ER group and/or after completing their Middle School studies. Table 7.6 summarises the views of the Case Study 3 participants on the matter.

Table 7.6: Case Study 3 participants' Choice Goals and Actions

Choice goals / actions	Remain in the ER group developing the same role	Remain in the ER group developing a new role	Become a mentor within the ER group	Engage in non-academic research	Start a technology-related UG course
Andrew	-	-	X	X	X
Daniel	-	X	-	X	-
Donna	-	X	-	X	-
Peter	X	-	-	X	-
Severus	-	X	-	X	X
Sheila	-	X	-	X	-

Interview data allowed the students' perspectives to be divided into five different choice goals/actions:

- (1) remaining in the ER group developing the same role within similar tasks;
- (2) remaining in the ER group developing a different role within more complex tasks;
- (3) becoming a mentor and/or adviser within the ER group (role which would be played by those who had already moved on to Secondary School); (4) engaging in non-academic research about technology-related topics; and
- (5) starting a technology-related undergraduate course.

This division enabled a better understanding of the students' rationale and offered a framework of the development of those participants' career interest stemming from their participation in the ER group. By setting goals/actions, without external support, participants seemed to have felt empowered by their own sense of responsibility. In other words, developing those mechanisms of personal agency, different degrees of career interest towards technology appeared to have been developed amongst the students; moreover, this interest might have been related to their positive self-efficacy beliefs, outcome expectations (Lent et al., 2002).

Peter, the only participant who claimed that he wished to remain in the ER group developing the same role, justified his choice goal/action by emphasising his good performance as a pilot and his lack of programming and robot building skills [Interview, EMEF Jose Mariano Beck]. Peter's goals supported and were supported by his views on his self-efficacy beliefs and were corroborated by observation data, which indicated that Peter was very focused and committed to providing the programmer with useful information in order to refine code during the training sessions for the FLL/2015 [Observations, EMEF Jose Mariano Beck].

Daniel, Donna, Severus and Sheila also expressed their desire to remain in the ER group; however, they would prefer to perform new roles related to robot building (Sheila) and robot programming (Daniel, Donna and Severus). Those four participants, who had been more involved in research, seemed to believe that they could replace those students who were going to become mentors and/or complete their Middle School studies. In this sense, Daniel, Donna, Severus and Sheila could develop engineering- and programming-related tasks during the following year.

Hence, it can be argued that those four participants' goals/actions had been developed, in an individual and self-sustained manner, towards technology. The next extracts summarise their views on the matter:

I want to participate in the competition team, next year (...) in any competition (...) I couldn't do it, this year because when the competition was about to start, I had to stop attending the ER workshop.

Sheila

I learned more, I learned how to code. Last year I wanted to be the pilot during the OBR, but (...) they [the team] didn't let me.

Peter

The first group was the best, in my opinion, because I already knew everyone. Now, I have to fit in with the new ones (...) I'm the oldest one and it's good because the new ones ask me to help them with things that they don't know (...) I try to help them with what I know (...) I've talked to our teacher about coming back next year as a mentor.

Andrew

Sheila, who had not participated in the team responsible for building or programming robots, had the opportunity to be in the main team for the OBR at the beginning of

2015; however, for reasons further discussed in Section 7.2.1.5, Sheila had to leave momentarily the ER group. After having returned to the group, Sheila participated in the Regionals FLL and won the Best Research Prize alongside her teammates. Thus, the choice goal which Sheila had shared during the interview has already been achieved, since she became more involved with building and programming robots [Interview with the teacher, EMEF Jose Mariano Beck].

Peter's choice goals, which is related to continuing his role as a pilot within the ER group, seemed to reflect his preferred ER approach, ER competition, and a personal preference towards a leadership position, with which Peter appeared to feel comfortable [Observations, EMEF Jose Mariano Beck]. Nevertheless, documentary analysis revealed that Peter had successful outcomes when developing other roles and/or multitasking [MNR and FLL Documents, EMEF Jose Mariano Beck]. Andrew, who also to a certain extent wanted to remain in the group developing a similar role, seemed to have understood that, rather than being a leader amongst the youngest students, he would be more helpful in the role as an advisor and/or a mentor. As many of his fellow former participants in the ER group at Beck School, Andrew remained in the ER group as the students' mentor, which might have influenced the development of his interest towards Informatics and Robotics – alongside the scholarship to continue working with the recycling-related robotics project Clean World.

All six participants identified seeking more information about technology, especially robotics, in an informal manner as a choice goal/action. Andrew and Severus, alongside that interest in non-academic related research, revealed interest in pursuing opportunities to develop their undergraduate studies in technology. Andrew explained that he would like to study Informatics in order to focus on coding [Interview, EMEF Jose Mariano Beck]. Severus described how his computer skills had been developed to that point as follows:

I learned how to email, I didn't even have an email address (...) I learned how to set up the Wi-Fi and the screen monitors, at home, and that has helped me a lot. I learned how to set up the antivirus (...) my cousin started attending an Informatics course, but she gave up, so I kept the articles she had and read them at home.

Severus

Severus suggested that having access to technology at home, technology-related study materials and/or direct contact with people who had chosen such field was an advantage to him. The opportunity to practice and research “informally” (or, outside an educational setting) might have influenced the choice goal of Severus, as well as his interest towards technology. Peter also appeared to have been encouraged by a someone who had already developed such work. According to Peter, a colleague whose graphics had been well designed inspired him to learn more about the topic. Peter developed a blog and MNR-related research by applying what he had learned about graphic design from that colleague [Researcher’s observations, EMEF Jose Mariano Beck].

Findings revealed that, although the participants’ choice goals/actions were important for the development of their career interest, factors of support and barriers can also meaningful influence their choices. The next section discusses the findings related to those specific factors

7.4.5. Within-case analysis of supports and barriers

Interview and observation data revealed that the development of the Case Study 3 participants’ career interest towards technology might have been influenced by supporting factors. Table 7.7 summarises the participants’ perspectives regarding the matter.

Table 7.7: Supporting factors identified by the Case Study 3 participants

Participants	Emotional and financial support	Example from role models	Opportunities for skills
Andrew	X	X	X
Daniel	X	-	-
Donna	X	-	X
Peter	X	X	X
Severus	X	X	-
Sheila	X	X	-

All the participants emphasised the importance of having their families supporting their participation in the ER group. Peter and Severus, as explained in the following extracts, could rely on their mothers’ support:

My mother keeps telling me that, after four years insisting with the teacher to be accepted in the group, the least I can do is to stay (...) so, it's essentially my mother who supports my participation in the group.

Peter

My mother always supported me because she knows (...) since I was in second grade, I'd come over to the ER Group room and follow them [members of the ER group] (...) I already liked robotics, since then I wanted to be here.

Severus

The accounts suggest that both the participants wanted to participate in the ER group since the beginning of their primary studies. They also highlighted the role that both their mothers had been playing in recognising their desire to be involved with ER and in acknowledging their efforts to participate actively within the ER Group. Interview data revealed that the emotional and financial support of those mothers had been crucial for the participation of Severus and Peter in the MNR and Nationals FLL – since both events were undertaken in a different state in Brazil [Interview with the Teacher, EMEF Jose Mariano Beck].

Andrew, Daniela, Donna and Sheila identified more than one source of financial and emotional support within their families. Andrew and Daniel, whose siblings had already participated in the ER group at Beck School, seemed to have had significant support from several family members. In this sense, not only could Andrew and Daniel rely on their parents' and siblings' support, but they could also count on their understanding and guidance. Despite having been the first members of an ER group in their families, Donna and Sheila had their mothers' and sisters' support. The extracts below represent those students' perspectives on the matter:

My mother tells me that I mustn't skip the ER classes (...) she encourages me (...) I also wanted to participate the group because everyone in my family attended this course (...) my brothers attended the same ER classes.

Daniel

My sister asks me things like "weren't you supposed to be at the ER class?" (...) my mother supports me financially.

Donna

Daniel highlighted his mother's role in encouraging him to take advantage of the opportunities that participating in the ER group might provide. Since both of his brothers learned about robotics, team work and travelled to other states representing the ER group, Daniel's family seemed to expect the same achievements from him.

Donna, whose mother's financial support was recognised as fundamental, appeared to have been encouraged not to skip the ER classes by her sister. Interview data evidenced that Donna and Sheila had younger sisters who admired their work within the ER group and tried to help them at home with the ER activities. Their mothers, who were the only parents on who Donna and Sheila could count, had also been playing an important role in supporting them emotionally and financially. Both, Sheila and Donna, could participate in the Regionals FLL and Donna participated in the Nationals.

The second source of support that four of the six participants identified was the example of role models. According to the coach within the ER group, the students had had contact with many people who could have been perceived as role models (e.g. member of other ER group, teacher) [Interview, EMEF Jose Mariano Beck]. Severus and Sheila explained the importance of having role models as follows:

During the Nationals FLL, I got really curious about the work of Team Jedis (...) their robot had a better gravitational point, a specific gravity centre.

Severus

Our teacher inspires me because she's so intelligent and smart.

Sheila

Those accounts exemplify how role models could impact and/or inspire those participants. For Severus, an ER group comprising older students and their teacher presented a certain work which seemed to have impressed him and, therefore might have develop his interest in a technology-related career, since after having met that team, during the Nationals FLL, Severus became interested in the relationship between robot building and Physics [Researcher's field notes, EMEF Jose Mariano Beck]. Sheila, who felt inspired by her teacher, appeared to have developed an interest in the everyday work of a teacher involved with ER rather than a specific

aspect of ER. Findings indicated that the range of those role models was limited to those with whom the participants would encounter at Beck School and/or during the ER-related events, since the participants, for being Middle School students, might not have had many opportunities and/or interest in contacting professionals within the technology field [Researcher's field notes, EMEF Jose Mariano Beck].

Opportunities for skill development within the ER group was identified as a supporting factor by Andrew, Donna and Peter. Several opportunities were available for the ER students at the school, since the curriculum was based on learning experiences. In other words, the development of skills and ER topics had been underpinned by type of ER approach being developed during a given period. For example, after the first semester, opportunities for robot building, and programming would be more common than during the first semester, when most of the robotics projects would have been developed (e.g. MNR projects, "Clean Game") [Interview with the teacher, EMEF Jose Mariano Beck]. The following extracts present the participants' perspectives about the opportunities for the development of skills.

I like building games (...) I learned how to programme, and I didn't know about that before participating in the ER group.

Donna

We are developing toys, videos, and games for children, so they can learn how to recycle and teach their parents at home.

Peter

Donna, who had worked almost exclusively with research at that point, seemed to have perceived her involvement with the ER projects as opportunities for the development of skills (such as programming). Peter, in turn, attributed to the development of toys (with Arduino) and games (through the Edilim software) the opportunity for developing technology-related skills. Both participants identified the ER classes as the context in which opportunities for the development of skills had been provided. However, those opportunities seemed to have allowed the students to find different strategies to solve problems or achieve new outcomes, as Peter exemplified in the following quote:

We developed a poll and asked the adults in our own community if they recycled at home (...) we provided three possible answers: yes, no or maybe (...) most of the people answered “no”.

Peter

After having been working on solutions for the recycling-related issues within the community during the ER classes, the team decided to apply a questionnaire to the adults in the neighbourhood in order to verify whether their hypothesis could be confirmed. Since the response of the adults for the question related to their recycling habits had been negative, the team changed their target public for the campaign – from adults to children within their school. Another research proposal was drawn, and new actions were established. In so doing, opportunities for the development of other technology-related skills appeared [Interview, EMEF Jose Mariano Beck].

Despite not having been mentioned by the students, documentary analysis evidenced the team had been provided with opportunities for the development of skills during the following robotics events:

- Arduino workshops (Maristas’ Robotics Challenge 2014/2015);
- Arduino and drones’ workshops (MOSTRATEC 2014, Nationals FLL/2016);
- Robotics workshops (MNR 2014);
- Roboduino workshops (ER educational setting, 2015); and
- Lego workshops (FLL 2014/2016) [Documents, EMEF Jose Mariano Beck].

Alongside the supporting factors, the Case Study 3 participants also identified barriers for the development of their interest towards technology-related careers, as summarised in Table 7.8.

Table 7.8: Factors of barriers identified by the Case Study 3 participants

Participants	Social-structural barriers	Opportunities for skills	Cultural and gender barriers
Andrew	-	X	-
Daniel	X	X	-
Donna	X	-	X
Peter	-	X	X
Severus	-	X	-
Sheila	X	-	X

Daniel, Donna and Sheila identified social-structural barriers as factors that could limit the development of their interest in technology. Donna, for example, did not have a computer at home – which might have limited her opportunities to practice what she had learned during the ER classes. Observation data revealed that only Andrew, Peter and Severus had a computer at home in which they could practice their skills; however, because of the high cost, their access to the internet was restricted, almost exclusively, to the ER classes – when they could rely on the connection provided by the school. It can be argued that, for those students who did not have computer or access to internet at home, the ER group within Beck School might have been the only context where the development of technology-related skills could be nurtured [Researcher's field notes, EMEF Jose Mariano Beck].

Sheila explained that some parents did not want their children to have access to such opportunities for not being convinced that those learned skills could translate into a career. Sheila claimed that her mother, for example, wanted her to participate in programmes such as those at SASE, which offered pedagogical and psychological support, as well as health services. Sheila had to stop attending the ER classes because of her mother's decision and, only after having convinced her mother of the importance that such classes had to her, Sheila returned to the ER group. Examples such as that of Sheila reflected the lack of structure to guarantee the safety for those students who lived in socially-vulnerable communities. The teachers claimed that the concerns of Sheila's mother had not been unfounded or an isolated case, since deaths related to criminal activities had been affected many students and their families within that community [Interview, EMEF Jose Mariano Beck].

Although the opportunities for the development of technology-related skills had been mentioned as a supporting factor, four of the six participants identified such factor as a barrier, specifically because of two issues: (1) the ER group was the only one in that area; and (2) the ER classes occurred concomitantly to other school activities. Peter, who wanted to learn about Informatics, claimed that Beck School was the only educational setting available in the area where he could attend such classes. Daniel and Severus highlighted the fact that many activities occurred simultaneously and, therefore, the students who participated in more than one activity had to prioritise one of them. Severus explained such issue as follows:

I stopped attending the ER workshops because there was a new project

(...) I thought I couldn't attend both (...) I organised my schedule to attend the other project until 15:30 and, after that, go to the ER Group.

Severus

Daniel and Andrew had a similar issue, since they participated in a tennis project which occurred at the same time as the ER classes. Both Severus and Daniel claimed that such projects were rarely developed within their communities. Thus, it can be argued that the lack of opportunities for the development of skills contributed to those participants' need to dedicate their time and energy to projects other than the ER group [Researcher's Field Notes, EMEF Jose Mariano Beck]. Andrew, in turn, seemed to have prioritised the ER group for reasons related to employability, as he explained in the following extract:

You can be referred to a job through PPE (...) I stopped enjoying it [Tennis workshops] a little (...) before the ER classes, I used to go to every class, and, now, I stopped going as much as I used to.

Andrew

The possibility to be offered a position within the First Job Programme (PPE – Programa Primeiro Emprego) seemed to have encouraged Andrew to take the ER classes more seriously than the Tennis workshops. Documentary analysis evidenced that Daniel, who participated in the Tennis workshops alongside Andrew, had not decided whether to prioritise the ER group or the tennis classes. Donna, in turn, appeared to believe that the ER course was more likely to provide her with opportunities to develop the abilities which could be used in a future career than the Tennis workshop [Researcher's Field Notes, EMEF Jose Mariano Beck].

Those barriers, such as overcoming the lack of opportunities for skills development and the overlapping of activities timetables, could be considered as distal influences, since those are factors which are not directly related to the object of study (Lent et al., 2002). Another distal influence which was mentioned by four of the six Case Study 3 participants was the cultural and gender-role socialisation processes. Those factors could potentially influence the development of the participants' interest towards technology careers. Donna and Sheila identified gender issues whereas Peter and Severus identified socialisation issues. Sheila, for example, explained that, because she had prioritised the activities within the ER group, she neglected other activities (such as her chores at home) [Interview, EMEF Jose Mariano Beck].

As a result, Sheila's mother forbade Sheila to attend the ER classes, as explained in the following extract:

Because I didn't like to wash the dishes, clean the bathroom and tidy up my bedroom, my mum punished me (...) I had to start doing all those chores, so she would allow me to return to the ER activities.

Sheila

Sheila perceived her mother's decision to be gender-motivated, since the same had not happened to her male colleagues. The household chores were found to have been established as a female job by the participants' parents. Such a predetermined idea about the role played by women in the family can be reproduced within the entire community, which might become a factor of barrier and influence the development of the female participants' interest towards technology-related careers [Researcher's field notes, EMEF Jose Mariano Beck]. Donna also identified gender barriers as part of her experience within the ER group, as explained below:

A friend of mine wanted me to attend the ER classes with her and, at that time, there were no girls in the group (...) I wanted to participate. Actually, I'd been wanting to be part of the group for quite some time by then (...) I'd be ok if I were the only girl (...) I've been relying on them [male colleagues] now more than I used to.

Donna

Donna stated that she could have started attending the ER classes before; however, the lack of female students in the group influenced her decision. However, Donna believed that she could have been the only female student in the group and acknowledged her male colleagues' support. Both Sheila's and Donna's accounts revealed that the school community and/or their families might have not expected and/or accepted the participation of girls in the ER group. Nevertheless, the following extract presents Sheila's account about her family's reaction when they learned she was part of an ER group.

The boys in my family really enjoy the idea (...) it seems very important to my brother to have a sister who is actually attending ER classes (...) I even believe that participating in this group will give me some advantage in the future because I'll be one of the few female professionals working with technology.

Sheila

Sheila believed that her family, especially her brother, felt proud of her being one of the only female students in the ER group and she acknowledged that such opportunity can be professionally advantageous to her in the future. Thus, it can be argued that Sheila overcame the gender barriers and that her active participation within the ER group had an impact on her family. Furthermore, having chosen to be involved in technology-related activities, despite clear gender-motivated prejudice, seemed to have been a positive experience, to that point, for both female participants.

Peter identified cultural barriers which could have influenced the development of his interest in technology-related careers. The following extract presents Peter's account about such issue:

I was bullied a lot (...) I used to fight with the older ER students all the time because they bullied me (...) I was fat...well, I am fat and that was why they bullied me (...) I asked our teacher if I could be in the robotics team anyway (...) I was very proud of myself and my efforts because I continued participating even though I was being bullied and was the youngest in the group (...) after my first year here [at the ER group], the older students graduated and went to another school (...) the only ones who stayed here were Andrew, Donna, Daniel and myself.

Peter

Peter claimed to have suffered with bullying during the entire year of 2014; however, in 2015, when this study was undertaken, there were no claims regarding bullying.

Considering the participants' behaviour and overall atmosphere within the ER group, the school and/or the ER group must have been intolerant towards any sort of bullying [Researcher's field notes, EMEF Jose Mariano Beck]. Peter attributed to his teacher an important role in the process of dealing with such issue and helping him to overcome that barrier. The teacher seemed to have encouraged the students to develop a safe space through socialisation and, mostly, dialogue. Moreover, a more democratic and inclusive policy appeared to have been implemented, since the participation in important ER events were no longer exclusive for older students as it used to be before 2015 [Researcher's field notes, EMEF Jose Mariano Beck].

This section has focused on the supporting factors and barriers which might have influenced the development of the Case Study 3 participants' interest in technology-

related careers. The next section discusses the findings related to the development itself of such interest.

7.4.6. Within-case analysis of the development of career consideration towards technology

The Case Study 3 participants identified career paths, related and unrelated to the technology field, in which they had been interested before and after participating in the ER group. Table 7.9 summarises the participants' accounts.

Table 7.9: Case Study 3 participants' career interests and considerations

Participants	Previous interest unrelated to the technology field	Previous interest related to the technology field	Career consideration unrelated to the technology field	Career consideration related to the technology field
Andrew	Tennis Player	-	Tennis Player	Computer Software Engineer
Daniel	Mathematician	-	Mathematician	Robotics
Donna	Fashion Designer	-	Fashion Designer	Robotics
Participants	Previous interest unrelated to the technology field	Previous interest related to the technology field	Career consideration unrelated to the technology field	Career consideration related to the technology field
Peter	Journalist	-	-	Graphic Designer
Severus	Biologist	-	Biologist	Informatics
Sheila	Volleyball Player	-	-	Robotics Teacher

All the participants claimed to have developed interest in the technology-related careers, amongst which two, Peter and Sheila, stated to have lost their previous interest in a career that was unrelated to the technology field. The participants' interests seemed to agree with the self-efficacy and outcome expectations beliefs which had been developed from 2014 to 2016. For example, Andrew's and Peter's interests in software development and graphic design, respectively, were related to their personal beliefs regarding their competences, which was previously analysed (see Section 7.2.1.1). Although Daniel, Donna and Severus could not specify jobs in which they had been interested, they identified the technology fields whereas Andrew, Peter and Sheila were able to pinpoint the careers that they intended to pursue. Regardless, such findings evidenced that the ER activities influenced the Case Study 3 participants' career interest. Peter and Sheila explained their perspectives as follows:

Before the ER classes, I wanted to be a journalist or a photographer (...) Well, I still want to, but, now, I want to be a designer or work with Informatics.

Peter

I want to be a Robotics Teacher when I grow up because I used to play volleyball, but, now, I like robotics much more than volleyball (...) our teacher has inspired me because she's so intelligent and nice.

Sheila

Data revealed that, despite his claims of being more interested in graphic design and Informatics, Peter had been combining his interests in photography and in technology to develop his blog and during the team projects/challenges. Sheila, in turn, claimed to have been inspired by the teacher who had been developing the ER classes at Beck School since 2007. The teacher seemed to have become a role model to Sheila in terms of working with technology and providing opportunities for skills development. Andrew, who had been previously interest in becoming a tennis player, identified an interest towards Informatics after having started to attend the ER classes. Andrew could also specify his intention to become a Computer software engineer.

Andrew, Peter and Sheila had been involved in several learning experiences within the ER group, which might have enabled them to identify their strengths and weaknesses regarding their technology skills and, therefore, specify their career interests. Donna and Daniel, who alongside Severus, could not specify their career interest explained their perspectives as follows:

I have a chance to learn much more by participating in the robotics group than doing something else like attending the tennis workshops (...) I'm only practicing a sport (...) I don't know where it's going to take me in the future (...) I believe that the robotics group can "show" me a future, a career.

Donna

I still think about becoming a Mathematics teacher, but I also started to be interested in robotics (...) so it can also be a job, I think.

Daniel

Both participants did not pinpoint the directions towards which they intended to follow in terms of career interest; however, their accounts indicated the impact that having participated in the ER group had on their interest in technology-related careers. Donna acknowledged that the ER classes were more likely to enable her to pursue a career than the tennis workshops. Her interest in robotics can be a result of the learning experiences with which she had been involved. Daniel, on the contrary, could not state conclusively that his interest in Mathematics had been surpassed by his interest in robotics or vice-versa. It can be argued, though, that the ER classes had provided Daniel with an alternative career.

This section has discussed the findings about the development of the Case Study 3 participants' career interest. The participants' interests agreed to the relationship between their self-efficacy beliefs and outcome expectations. Hence, we argue that this Case Study has corroborated the SCCT theory, which relates one's self-efficacy beliefs and outcome expectations to the development of one's interest towards a topic and/or field in which one has been consistently proficient. The next section focuses on the development of the participants' confidence towards technology.

7.4.7. Within-case analysis of the development of confidence towards technology

The participants' perceptions about their confidence towards technology (summarised in Table 7.10) was analysed in relation to the development of their interest in careers within the technology fields.

Table 7.10: Case Study 3 participants' development of confidence towards technology

Confidence towards technology	Unchanged / changed negatively	Changed positively
Andrew	-	X
Daniel	-	X
Donna	-	X
Peter	-	X
Severus	-	X
Sheila	-	X

All the Case Study 3 participants claimed to have developed their confidence towards technology after starting to attend the ER classes. The participants

attributed such confidence development to two factors: (1) the knowledge they had gained by attending the ER classes; and/or (2) the capacity to overcome negative emotional states during the ER course. The quotations below summarise the participants' perceptions on the matter:

Before, I knew almost nothing about computing (...) because of the ER classes, I started to learn several things.

Peter

I feel more confident because working on something that you don't really know anything about is one thing but working on something that you know is something else.

Severus

Now I know that if I continue attending the ER classes, I'll learn more and more each day (...) otherwise, I'd be on the streets, learning nothing.

Daniel

I really think I'm more confident with technology than before the ER classes.

Andrew

Those four participants' accounts evidenced a relationship between the development of their confidence and their participation in the ER group. The lack of external factors which could have contributed to such development supports the argument that Andrew, Daniel, Peter and Severus had been offered limited opportunities outside the ER group to develop and/or improve their technology skills. For Daniel, the ER classes seemed to have allowed him to occupy his time in a more productive manner than being on the streets.

The female participants, Donna and Sheila, claimed that not only did the ER classes help them to develop confidence towards technology but they also enabled them to overcome their personal fears of technology. Donna explained her viewpoint as follows:

Before the ER classes, I knew nothing about technology and, now, I know a little bit more (...) I used to be very afraid of dealing with technology or of breaking a computer. Now, I know some stuff, so I'm not afraid.

Donna

Although Donna did not share how her fear of technology used to impact her everyday life, she appeared to have overcome that fear after starting to attend the ER classes. Donna could have required more time to develop technology skills and/or confidence towards technology; however, interview and observation data revealed that Donna had been able to achieve similar outcomes as those of her colleagues within the same amount of time. Sheila's fear of technology seemed to have been triggered by an actual incident, as suggested by the following extract:

Before the ER classes, I was afraid of dealing with technologies such as mobile phones, computers, etc. I didn't even know how to use it and I actually broke my brother's mobile once while I was playing with it (...) it just stopped working (...) my brother told everyone in my family not to allow me to use their mobiles (...) nobody would let me use their phones (...) After I started attending the ER classes, I started to become much more confident about dealing with technology and I started to research, learn about technology and, now, everyone knows that they can trust me.

Sheila

Sheila's account clarified the connection between her participation in the ER group and the development of her confidence towards technology. Moreover, the research-based method, which was taught within the ER classes, seemed to have enabled Sheila to overcome her fear and lack of knowledge about technology. Sheila's desire to be perceived as someone who could deal with and know about technology by her family might have motivated Sheila to engage in research and practice within the ER group.

7.5. Conclusion

This chapter has discussed the findings regarding the development of career interest towards technology within the Case Study 3. All participants have developed interest towards technology-related careers to a certain extent. Andrew, Daniel, Donna and Severus considered pursuing careers which were both related and unrelated to the technology field whereas Peter's and Sheila's career considerations were solely related to technology. The Case Study 3 participants seemed to have developed both career interest towards technology and vocational behaviour – such as, promoting fairness at the workplace (Vondracek et al., 2014). Nevertheless, the limitations and set of barriers which had been imposed to those participants by their community,

families and/or socioeconomic contexts could influence negatively the development of such career interest. Table 7.11 summarises the findings related to the Case Study 3.

Table 7.11: Summary of the findings regarding the Case Study 3

Participants	Andrew	Daniel	Donna	Peter	Severus	Sheila
Self-efficacy	*Development of digital games *Robot development *Development of robotics projects *Informatics *Presentation	*Development of digital games *Robot Development	*Development of Digital Games *Presentation *Robot Programming *Informatics	*Piloting *Programming *Robot Development *Presentation	*Robot Development *Robot Programming *Research Presentation *Team Work *Informatics *RCX Programming	*Research presentation *Robot Development *Robot Programming *Development of digital games
Outcome expectations	-	-	-	-	*Winning the Best Team Prize during the Regional FLL *Being able to reproduce successfully all the learned activities	*Self-efficacy achievements *Winning the Best Research prize during the Regional FLL *Winning the Best Team Prize during the Regional FLL
Interests	*Informatics: creation of Android apps *MNR-related project topics	*Robot programming *Robot building	*MNR-related project topics *Robot building	*MNR-related project topics *Robot programming *Robot building	*MNR-related project topics *Robot programming *Robot building	*Robot programming *Robot building
Goals	*Become a robotics' mentor/ adviser *Informally seeking more knowledge about technology topics *Engage in academic courses related to technology	*Remaining in the group performing new roles (programming/engineering) *Informally seeking more knowledge about technology topics	*Remaining in the group performing new roles (programming/engineering) *Informally seeking more knowledge about technology topics	*Remaining in the group performing new roles (pilot) *Informally seeking more knowledge about technology topics	*Remaining in the group performing new roles (programming/engineering) *Informally seeking more knowledge about technology topics	*Remaining in the group performing new roles (programming/engineering) *Informally seeking more knowledge about technology topics

Participants	Andrew	Daniel	Donna	Peter	Severus	Sheila
Career consideration	* Computer Software Engineer * <u>Tennis player</u>	* <u>Mathematician</u> *Robotics (undecided about the role)	* <u>Fashion Designer</u> *Robotics (undecided about the role)	* Graphic Designer	*Informatics Teacher * <u>Biologist</u>	*Robotics Teacher
Broader view of labour market	*Limited contact with professionals from the technology field	*Limited contact with professionals from the technology field *Learned about computer engineering	*Limited contact with professionals from the technology field	*Limited contact with professionals from the technology field *Learned about careers such as automation engineer and informatics engineer	*Saw his attendance at the ER group as a "job" (similar to a work environment) *Learned about careers such as engineer, naval engineer, automation engineers, and robotics engineers	*Saw her attendance at the ER group as a "job" (similar to a work environment) *Learned about two careers: Lego designers and robot designers
Barriers	*No significant barriers identified	*Issues with his schedule *Distance between his home and educational settings providing technology courses	*Lack of access to technology and information *Gender-related issue	*Had to overcome bullying during the first year at the ER Group *Lack of access to technology and information at home	*Initial difficulties with peer interaction (shyness) *Initially had issues with his schedule	*Mother wanted her to attend another afterschool activity (unrelated to robotics) *Gender-related issue *Lack of access to technology and information at home
Supports	*Financial and emotional support from family *Teacher played an important role encouraging him to continue in the ER Group and developing skills *Had a brother who had already participated in the group *Had access to technology and information at home	*Financial and emotional support from family *Had two brothers who had already participated in the group	*Financial and emotional support from family *Teacher played an important role helping her to overcome shyness and learning technology skills *The robotics course has been giving her the opportunity to learn new skills	*Teacher played an important role encouraging him to continue in the ER Group and developing skills *Emotional support from family	*Financial and emotional support from family *Teacher played an important role helping him to overcome shyness and exploring leadership *Had access to technology at home	*Teacher helped her to manage an issue she had with her mother *Emotional and financial support from family

CHAPTER 8 DISCUSSION AND CONCLUSION

8.1. Introduction

This chapter discusses the findings in the light of the literature about ER, vocational psychology and learning theory. As seen in the previous chapters, there are indications of the development of interest towards technology careers in the Primary and Secondary School participants, as well as indications of development of technology skills. What follows is an in-depth review of the factors contributing or not to such developments and the consequences for future research in the ER field.

This chapter is divided into five main sections. Section 8.2 discusses the findings according to their relationship with the reviewed literature and the research questions which guided the investigation within this study. Section 8.3 addresses the contributions to knowledge that can be attributed to this thesis. In Section 8.4, the recommendations that this study proposes to researchers, policymakers and ER practitioners are presented and justified. Section 8.5 focuses on the limitations found throughout the development of this study as well as the possibilities for further research. Section 8.6 brings this chapter and the thesis to a conclusion.

8.2. The relationship between the findings and the reviewed literature on Robotics and Interest towards Technology Careers

This section presents an analysis of the relationship between this study findings and the bodies of literature which were reviewed in Chapter 2. In so doing, it is intended to offer a contribution to the debate, within the ER field, concerning the factors which might contribute to the development of interest towards technology. It is important to emphasise that both types of findings, those that corroborated and those that contradicted the arguments and/or theoretical perspectives within the reviewed literature, are discussed in order to respond the research question and subsidiary questions which informed this study.

8.2.1. Main Research Question: To what extent does participation in Educational Robotics within educational settings influence young learners' interest in technology careers?

According to the SCCT theory, development of positive self-efficacy and outcome expectations beliefs stemming from participation in learning experiences could lead to the development of interests and goals towards a career (Lent et al., 1994). Different degrees of interest and goals were found amongst the students who participated in this study. For example, some of the participants changed little and/or nothing in terms of their interest towards technology careers whereas others were able to sustain such interest (see Chapters 5, 6 and 7 for further details).

The SCCT framework for the development of career interest highlights the connection between the development of interest and goals stemming from self-efficacy and outcome expectations beliefs as indicators of the development of career interest itself.

It is argued that one's vocational interest is strongly related to the academic interests that one develops towards a certain field (Athanasou and Van Esbroeck, 2008; Brown, 2002; Vondracek et al., 2014). According to Lent et al. (2002):

Specifically, SCCT asserts that people form enduring interest in an activity when they view themselves as competent at it and when they anticipate that performing it will produce valued outcomes. Conversely, people are likely to fail to develop interests in (or may form aversions to) activities in which their self-efficacy is weak or when they anticipate receiving neutral or negative outcomes (p. 265).

In this study, participants stated having developed interest towards technology (such as programming or robotics) alongside the development of goals towards the technology field. Goals are individual actions which are started and sustained by a certain person (Vondracek et al., 2014). Thus, according to participants' statements, it was possible to divide such goals into the following types:

- (1) academic-related goals (in the Secondary School level): such as taking a secondary-level technician course in electronics;

(2) academic-related goals (in the Higher Education level): such as intention to take an Undergraduate course in Computer Science; and

(3) a career-related goal: such as working in a company related to the technology field or becoming an entrepreneur within the same field.

Furthermore, it was considered that the participants had developed a continuous interest towards technology careers when their academic-related goals had been just recently developed. In cases which the participants had developed both career-related and academic-related goals towards technology, their interest seemed to be more consolidated. Table 8.1 illustrates such argument by presenting a summary of the participants' interests and goals.

Table 8.1: Summary of the participants' interests and goals

Participants	Interests	Academic-related goal (Secondary Level)	Academic-related goal (Higher Education Level)	Career-related goal
CASE STUDY 1				
Albus	Software development Game design	Starting another technology-related course	None	Game designer
Darwin	Software development / programming Informatics	Creating a game; Taking another technology-related course	None	Software developer
Nathan	Software development	Starting another technology-related course (with scholarship)	Undergraduate course in Computer Science	Software developer
Ulrich	Informatics Engineering Skills	None	None	Entrepreneur (computer repairs)
CASE STUDY 2				
Amelia	No interest towards technology was identified	None	Physical Educator	None
Andrea	Engineering and Programming	None	Physical Educator	None
Anne	Electronics (components) Informatics (hardware)	None	Undergraduate course in the technology field (Electronics)	Working for an electronics company
Ethelyna	Robotics Challenges	Participating in a robotics challenge in the following year	None	Volunteering as na advisor at CESMAR
Luisa	Programming Professional skills	None	None	Becoming a Pedagogue; Working within the technology field to pay for HE studies
Michelle	HTML, Java, JavaScript, C++, Autocad, Computer Science	Participating in a robotics challenge after the course	Computer Science (2016)	Volunteering as a mentor; Working for a company in the technological field
CASE STUDY 3				
Andrew	Informatics; Android apps; MNR-related topics	None	Becoming a ER mentor; Taking courses related to the technology field	None
Daniel	Robot programming and engineering	Remaining in the group (performing new roles)	None	None
Donna	Robot engineering; MNR-related topics	Remaining in the group (performing new roles)	None	None
Peter	Robot programming and engineering; MNR-related topics	Remaining in the group (performing new roles)	None	None
Severus	Robot programming and engineering; MNR-related topics	Remaining in the group (performing new roles)	None	None
Sheila	Robot programming and engineering; MNR-related topics	Remaining in the group (performing new roles)	None	None

The extent to which career interest towards technology was developed amongst the participants seemed to be related to the following factors:

- (1) the participants' level of education; and
- (2) the ER curricula within educational settings where the participants had been attending ER classes.

The first factor can be illustrated by the participants' choice goals. For example, the secondary school students who participated in Case Study 2 were expected to have academic-related and career-related goals compatible with their education level. Thus, it was not surprising to have found that participants such as Michele had developed academic goals and planned to start an undergraduate course. The middle school students who participated in Case Studies 1 and 3 were found to have focused their academic goals in their most likely next academic step: Secondary School. Andrew, the oldest Case Study 3 participant, was about to graduate from Primary School, hence, it would be expected that his developed goals would be towards Secondary School level technology courses or beyond, as they were.

The second factor is related to the connection between the curriculum within each educational setting and the development of the participants' interest towards technology careers. The Case Studies 1 and 2 participants seemed to have developed career interest towards technology to a larger extent than those participating in Case Study 3. Such findings were not considered surprising because of their ages and the type of curriculum that was developed within their ER educational settings, which did not focus on the integration of School and the world of work – the opposite of what was found in the contexts where Case Studies 1 and 2 were undertaken. All three case studies shared another common characteristic: their curricula were based on multi-ER approaches. In other words, all participants had been provided with the opportunity to engage in ER projects, ER classes and ER competitions during their participation in the ER groups.

Reviewed literature in ER indicates a connection between the type of ER approach developed within an ER educational setting and the development of career interest towards STEM (see Craig, 2014; Duran et al., 2014; Nugent et al., 2008; Nugent, Barker, Grandgenett, et al., 2014). However, limited evidence can be found which indicates that ER approaches might have an impact on the development of interest

towards technology careers (Craig, 2014; Duran et al., 2014). This study findings revealed that most participants (a) developed an interest towards technology careers to a certain extent (from academic-related to a career-related goal); as well as (b) started to consider careers in the technology field as a result of their participation in ER activities.

A difference in the extent to which participants developed choice goals towards technology was found between the Case Studies 1 and 2 and the Case Study 3. The Case Study 3 participants seemed to have developed more social-related goals than those participating in Case Study 1. For example, Andrew was the only Case Study 3 participant who developed an academic-related goal towards technology – which might have been related to (1) his age; (2) his education level; and (3) his family support. Andrew's fellow Case Study 3 participants, who were much younger than him, appeared to have their choice goals focused on technical courses (within the Secondary school level).

The Case Studies 1 and 2 participants, however, despite having come from similar socio-economic backgrounds, could be considered lucky to have been matriculated and studying in an educational setting providing technical education. Furthermore, the Case Study 1 participants could attend technology-related technical courses at the same educational setting as they had been attending the ER classes. Those differences showed the limitations of each educational setting in terms of providing learning opportunities that could be helpful to bridge the gap between Primary/Secondary School and the world of work. The next section discusses four subsidiary research questions which guided this study.

8.2.2. Subsidiary Research Questions

The subsidiary questions of this study were designed to address the factors involved in the development of interest towards technology and were informed by the SCCT (Lent, et al., 1994). They tackled the following issues: (1) an evaluation of the learning experiences that were more successful in nurturing the development of interest towards technology careers; (2) whether the ER approaches developed in the investigated educational settings had influenced the participants' consideration of a career in technology; (3) which barriers and supports were found, according to participants, teachers and mentors/tutors' perceptions; and (4) the development of a

broader vision of the technology labour market as a consequence of participating in ER groups for an extended period of time. Criteria to respond those questions are detailed in this section.

8.2.2.1. Sub-question 1: To what extent does participation in Educational Robotics within educational settings provide young learners with relevant technological skills?

To determine whether the participation in ER educational settings provided the participants with meaningful technology skills, a framework for comparing technology skills was created (see Chapter 4). The technology skills developed through ER approaches in each case study was then compared to this framework (see Chapters 5, 6, and 7) and are further discussed. Findings revealed that two factors seemed to influence the development of technology skills in the cases studied: (1) the type of curriculum implemented in each educational setting; and (2) the instructional strategies underpinning teaching approaches.

Firstly, findings revealed that a curriculum aimed to provide students with technology skills (Case studies 1 and 2) had more success on that task than the case where there was not a curriculum *per se*. Secondly, there are indications that the curricula which had been underpinned by guided discovery learning model of teaching (Case Study 3) seemed to have provided the students with less opportunities to develop technology skills. Case Studies 1 and 2, however, presented curricula which had been underpinned by a peer discovery learning model of teaching and, therefore, provided the students with more opportunities to develop technology skills. They also presented better results in terms of the extent to which they develop interest towards technology careers.

As previously mentioned, there has been limited evidence supporting the argument that technology skills can stem from the participation in ER projects and classes (e.g. Duran et al., 2014; Nugent et al., 2010). The impact of ER on the development of technology skills within ER competitions has been even less reported; although, there has been data indicating the opposite – the nondevelopment of technology skills by those participating in ER projects (Nugent et al., 2011). However, this study presents evidence that most of the participants developed technology skills. The engagement in ER learning opportunities for a long period combined with the implementation of a

multi-ER approach curriculum within the educational settings seemed to have contributed to the development of the students' technology skills. Instructional strategies, such as peer discovery learning, seemed to have been more fruitful in terms of nurturing technology skills in all the Case Studies.

The curriculum implemented in Case Studies 1 and 2 focused on the development of technology skills, whereas the curriculum on Case Study 3 did not. Findings regarding Case Study 3 evidenced that the development of technology skills was intertwined with the following factors:

- (a) the absence of a curriculum per se, since the curriculum depended on the activities in which the educational setting was involved. That factor could have limited the range of learning topics and skills with which the students were provided;
- (b) the lack of infrastructure to support skills and learning topics regarding technology which resulted in the acceptance of a reduced number of students; and
- (c) the absence of technology specialists to work with the students (the ER teacher's expertise was languages rather than technology).

In order to support such argument, the experience of Sheila – a Case Study 3 participant – can be emphasised. According to Sheila, when she started to attend the ER classes, she could not participate immediately in more complex activities, such as FLL and MNR. Two factors contributed to that: (1) the lack of enough robotics kits to build two different teams, one comprising new students (like her) and another with those who had been in the ER group for longer; and (2) the lack of students with enough engineering and/or programming skills who could have helped her and her colleagues to learn those skills faster. Severus, Sheila's colleague, went through a similar situation, since he reported that it had taken him approximately a year to learn how to programme an Arduino through distance learning, mostly, until he could develop a project and a robot for the MNR. The same learning and skill development opportunities would have happened within less time at the educational setting where Case Studies 1 and 2 took place due to the availability of equipment and teachers that were key for the advancement of their studies.

This section discussed the second research question of this study. Findings indicated that the educational settings in which Case Studies 1 and 2 took place seemed to have provided students with more opportunities to develop technology skills. Two factors were found to have contributed to that: (1) the curriculum implemented in these contexts, which focused on the development of technology skills; and (2) the instructional strategies underpinning teaching approaches (peer-assisted learning). Limitations to the development of technology skills seemed to be related to a lack of an updated curriculum for Basic Education addressing the role of technology in Education.

8.2.2.2. Sub-question 2: Which learning experiences are more effective nurturing career interest in technology?

According to Lent and Worthington (1999) and Lent et al. (2002), learning experiences in which one succeeds can encourage the development of skills, self-efficacy, outcome expectations, and, in a long-term, career interest. Being successful in such learning experiences might also help to refine skills and abilities – what could be considered a cycle of positive performance attainment (Vondracek, et al., 2014). However, being unsuccessful or not having a certain sense of achievement can result in the opposite effect.

The participants' perspectives helped to identify which learning experiences had been more effective to nurture interest towards technology careers. Those learning experiences were compared considering (a) the degree of interest in technology-related careers that they might have nurtured; and (b) the relationship between the development of career interest and the ER approaches emphasised by the participants. Findings indicated that multi-ER approach curricula had provided an extensive variety of learning activities. Furthermore, the availability of such variety might have contributed to the development of interest towards technology career by a higher number of participants. However, despite having played an important role in nurturing students' interest, evidence showed that the individuals' purposes might have influenced the development of that interest more than specific learning activities.

Table 8.2 summarises the relationship between the participants' preferred ER approach and the development of their interest towards technology careers.

Table 8.2 Relationship between ER approach and technology-related career interest

Participants	Preferred ER approach	Developed interest towards technology-related careers
CASE STUDY 1		
Albus	ER as a tool in learning (classes)	Academic- (Secondary School) and career-related goals
Darwin	ER as a tool in learning (classes)	Academic- (Secondary School) and career-related goals
Nathan	ER as a tool in learning (classes)	Academic- (Secondary School and Higher Education) and career-related goals
Ulrich	ER as a tool in learning (classes)	Career-related goals
CASE STUDY 2		
Amelia	ER projects	None
Andrea	ER projects	None
Anne	ER projects and ER competitions	Academic- (Higher Education) and career-related goals
Ethelyna	ER projects and ER competitions	Academic- (Secondary School) and career-related goals
Luisa	ER projects and ER as a tool in learning (classes)	Career-related goals
Michelle	ER competitions	Academic- (Secondary School and Higher Education) and career-related goals
CASE STUDY 3		
Andrew	ER competitions	Academic- (Secondary School) and career-related goals
Daniel	ER competitions	Academic-related goals (Primary School)
Donna	ER projects	Academic-related goals (Primary School)
Peter	ER competitions	Academic-related goals (Primary School)
Severus	ER projects	Academic-related goals (Primary School)
Sheila	ER projects and ER competitions	Academic-related goals (Primary School)

The findings summarised in Table 8.2 corroborate the argument that ER projects and classes can potentially develop interest towards technology careers in Primary and Secondary school students (Craig, 2014; Duran et al., 2014). As discussed in Chapters 5, 6, and 7, most participants developed, to a certain extent, career interest (academic-related, career-related, or both) towards technology. The participants who were perceived to have established both academic- and career-related goals were those who had been more involved in the process of developing a vocational behaviour towards technology. In other words, findings confirmed the perspective of Lent et al. (2002) regarding the development of interest as key within the process of career choice.

Additionally, one could ask whether the Case Study 3 participants really developed interest towards technology careers or simply expressed their intention of continuing in the course in the following year. Lent et al. (2002) and Vondracek et al. (2014) propose that career interest involves the development of interests, goals, behaviours and attitudes that will eventually shape one's work life. Thus, pursuing that goal (remaining in the course and/or performing a new role), alongside other developed goals (such as, changing their career consideration beliefs and interests towards technology), can be perceived as the development of career interest.

Had all educational settings which were investigated implemented multi-ER approach curricula, would one ER approach have been credited more effective than others in fostering learning? To answer such a question, it is necessary to delve into the reasons to justify the participants' choice of learning activities. For the Case Study 1 participants, the ER classes were considered the most effective approach to nurture career interest towards technology. However, despite belonging to a similar age group and education level, the Case Study 3 participants identified ER competitions and ER projects as the most effective approaches to foster interest towards technology careers. Amongst the reasons why those participants presented different perspectives, the following shall be highlighted:

- (a) the Case Study 1 participants claimed that the student-teacher interactions and the impact on self-efficacy that those long-term interventions provided had contributed to the development of their interest toward technology careers. This claim seems to have a deep connection with the type of instructional methodology underpinning ER Classes (peer-discovery learning and guided-discovery learning). In the context where Case Study 1 took place, ER classes were planned to implement a constructionist approach, which, in that case, meant the availability of opportunities to explore the students' interests, theories and hypothesis while the teacher, as a facilitator, offered minimum guidance (Lee, Sullivan and Bers, 2013). Observation data and teachers' accounts allow the inference that this combination of approaches was beneficial for the process of implementing such constructionist approach in their cases;
- (b) the Case Study 3 participants claimed that they had been interested in fun and stimulating hands-on activities during which one can learn more about ER. During the ER classes, some students were finally able to have access to materials that had been unavailable for other activities, such as ER competitions, because of the limited number of kits. One has to be aware that the characteristics of the setting where Case Study 3 was undertaken might not be the reality of other educational settings. The participants also expressed their interest in activities that allowed them time to think, test hypotheses and develop teamwork. The ER approaches which encompass the characteristics that had been described by the participants are ER competitions and ER projects, respectively.

SCCT proposes that interest towards a given career does not solely stem from the development of self-efficacy (Lent et al., 1994, 2002); rather, sources such as personal inputs or career considerations must be considered (Lent et al., 1994, 2002; Nugent et al., 2014). For example, after learning how to perform all the roles available within the ER group in which he had been participating, Andrew – a Case Study 3 participant – was more interested in ER competitions than other ER approaches because they presented opportunities for him to network and learn something *new* about the robotics field. Nathan – a Case Study 1 participant – in turn, stated that, during the ER classes, he could receive the support that he needed (e.g. one-to-one time with teachers, classroom practice). Students such as Andrew, Anne, Daniel, Ethelyna, Michele, Peter and Sheila, whose preferred ER approach was ER competitions, develop interest towards technology careers as much as those whose preferred approaches were ER projects and/or ER classes. Hence, it can be argued that those findings corroborate what has been presented by the reviewed literature in terms of the potential of ER projects and classes to nurture career interest towards technology.

The reasons appointed by the participants to justify their preferred ER approaches reinforced the argument that students' purposes may have varied; however, regardless of their options, some students were provided with less opportunities to develop interest towards technology than other. For example, Ethelyna – a Case Study 2 participant – attributed her preference for ER competitions and ER projects to a personal interest in practice rather than theory. For Michele, Ethelyna's colleague, her preference for programming and testing robots under the pressure of a competition was the reason why she had chosen ER competitions as her favourite ER approach.

This section has discussed the learning activities which had been identified by the participants as the most effective in nurturing career interest. The potential of all three ER approaches (competitions, projects and classes) in providing opportunities for the development of career interest was acknowledged by the sixteen participants in the following manner:

- (a) four participants chose only ER classes;
- (b) four participants chose only ER competitions;

(c) four participants chose only ER projects (however, two of those four participants were found not to have developed career interest towards technology); and

(d) four participants chose both ER competitions *and* ER projects.

Findings revealed that the participants' personal preferences and the educational context in which those ER approaches had been developed contributed to the students' choices (see Chapters 5, 6 and 7). In other words, alongside the potential of the ER approach in fostering career interest, the students' personal interests and purposes need to be considered in order to understand their choices. Thus, the multiple types of learning activities which had been provided within each context where this study was undertaken contributed to the number of participants – fourteen of sixteen – whose interest in technology-related careers had been developed.

The next section discusses the impact of participating in an ER educational setting for an extended period on the consideration of a technology-related career by those who participated in this study.

8.2.2.3. Sub-question 3: To what extent does taking part in Educational Robotics change students' previously intended career choices?

The literature about the impact of the participation in ER within educational settings on the students' career consideration is limited, especially when the only studies using ER approaches are taken into account. However, this study considered empirical studies on similar approaches to STEM in order to inform the investigation about the impact of extended participation (from six months to two years) in ER within educational settings on students' consideration of technology-related careers.

For the past decade, studies have been investigating and/or proposing ways to help students to understand better STEM careers to diminish the current gap between interest towards STEM and career choices towards STEM (e.g. Chase, 2010; Craig, 2014; Duran et al., 2014; Edzie, 2014; Gandhi et al., 2016; Hyslop, 2010; Keathly and Akl, 2007; McMahon et al., 2004). Researchers have been trying to (a) find ways to help students to understand how to pursue a STEM-related career after Secondary School; and (b) know which factors have been discouraging students to pursue such careers.

This study aimed to investigate whether the ER within the selected educational settings could nurture career consideration towards technology and, how. Two factors seemed to have influenced most of the students whose beliefs regarding career considerations changed from the beginning to the final stages of this study: (1) the availability of several learning opportunities related to the technology field through the development of ER approaches; and (2) the role that mentors, tutors and teachers played as professional examples to the students.

As previously discussed in Chapter 5, 6 and 7, it was considered that the participants had *changed* their career consideration towards technology when: (1) they claimed to have been interested in a career which was unrelated to the technology field before having started to attend the ER courses; and (2) they claimed to have started considering a technology-related career after having been part of the ER groups for at least six months. Those who had been interested in a technology-related career before and after having started the ER courses were considered to have had their interest *reinforced*. The development of self-efficacy or outcome expectations beliefs were found to be key factors for the reinforcement of the participants' interest towards technology careers. Table 8.3 summarises such findings related to the three case studies.

Table 8.3: Summary of the participants' career considerations

Case Study	Career consideration towards technology	Career consideration unrelated to the Technology Field	Career consideration sustained throughout the period of study
Case 1	4	0	0
Case 2	6	5	1
Case 3	6	4	0

The Case Study 1 participants presented the greatest change in their career consideration, since all of them claimed to have changed their career consideration beliefs exclusively towards the technology field. The Case Studies 2 and 3 participants remained more flexible about their career considerations given that, despite having developed career consideration towards technology, they also developed interest towards other careers which were unrelated to the technology field. However, those beliefs were considered strong because they stemmed from cycles of performance attainment and development of interest towards technology careers *after* having participated in ER approaches.

It has been argued that the participation in learning opportunities, such as ER, can help students to access the technology field – which might result in the increasing and/or development of their interest in the field as well as in guidance to professional aspirations (see Chase, 2010; Craig, 2014; Duran et al., 2014; Gandhi et al., 2016; Keathly and Akl, 2007). Findings supported such argument because the participants indicated throughout this study that opportunities to access the technology field had been rare within their social contexts. Those opportunities were acknowledged and recognised as important for the development of the participants' career consideration for providing them with a set of learning experiences (ER projects, classes, competitions, science fairs, congresses, presentations, etc.) that enriched their knowledge about the technology field.

Case studies 1 and 2 had been designed to promote the contact with professionals within the engineering, technology, and computer science fields, those participating in Case Studies 1 and 2 had more opportunities to rely on mentors and to talk to experts within the technology field (heroes) than the Case Study 3 participants. These interactions are believed to be helpful when the issue is deciding towards a career path (e.g. Craig, 2014; Edzie, 2014; Hyslop, 2010; McMahon et al., 2004). For Craig (2014), ER mentors, tutors and teachers were fundamental to help those participating in her study to learn, to connect previous interests to new ones and their goals, to be exposed to several living examples who inspired them to continue pursuing STEM-related careers.

Special attention has been given to the issue regarding the gender gap within STEM careers (e.g. Edzie, 2014; Hyslop, 2010; Keathly and Akl, 2007; McMahon et al., 2004). A study conducted by McMahon et al. (2004) explored the potential benefits of information technology professionals mentoring directly secondary female students.

The study revealed that 6-month-period mentoring sessions helped develop the students' interest in IT to understand further the industry. Similar results were found by Hyslop (2010), who studied the positive outcomes stemming from career and technical education and its role in bridging the gap between graduating from school and pursuing a career in STEM. In an in-depth study about what could influence students to pursue and actually start STEM-related degrees, Edzie (2014) identified five factors: (1) helping others in their career; (2) having access to pre-

collegiate STEM exposure; (3) obtaining information about STEM career pathways; (4) establishing relationships with influential stakeholders; and (5) developing confidence in Maths and Science.

This study found that the mentoring/tutoring and the socio-economic contexts in which all participants lived played an important role in influencing their consideration towards technology careers. The primary and secondary students at CESMAR who participated in the Case Studies 1 and 2, respectively, for example, identified the financial relief that a technology-related career could represent to them and their families as the main reason for them to change their career consideration beliefs. Those perspectives were corroborated by the teachers' and mentors' accounts regarding the matter. Helping others – especially their family and community – was another factor identified by the Case Study 1 participants as an influence on their consideration towards a technology career. Those findings corroborate what previous studies suggested in terms of the importance of mentoring and having a sense of contributing to the community (Craig, 2014; Edzie, 2014; McMahon et al., 2004).

The Case Study 3 participants believed that their participation in the ER group could have a long-term impact on their lives due to a series of factors – such as age, education level and lack of pressure to contribute to the family budget. The factors influencing change in their career consideration beliefs seemed to be related to the exposure to ER approaches, the development of self-efficacy towards technology and the role that mentors, teachers and tutors played in their afterschool activities (e.g. Craig, 2014; Hyslop, 2010; McMahon et al., 2004). For example, the everyday work of the ER teacher was mentioned as one of the reasons why Sheila started to consider pursuing a career as an ER teacher. The positive impact that Sheila's teacher had on her and her colleagues influenced the development of Sheila's interest in such career. Other participants, in turn, seemed to have developed interest in a technology-related career because of their interactions with members of other ER teams and professionals within the technology field during ER events (e.g. science fair, competition, congress, etc.).

Most participants in this study changed their beliefs about career consideration by adding the technology field as a possibility. This section has discussed the main reasons why such changes happened. Three factors were identified as key to this process: (1) the pressure that the students suffered to overcome their socio-

economic situation; (2) the role that mentors, teachers and tutors played in bridging the gap between the professional world and the educational settings; and (3) the impact that the participants sensed that they could have in their own community. The first factor was found to have been addressed insufficiently by the literature on the topic. Such pressuring factor was found to be felt by those participating in Case Studies 1 and 2 who were concluding their primary and secondary studies, respectively. Since students can be legally hired as interns from the age of 14, internship opportunities could be available to them, even at the educational setting where they attend ER classes. The second and third factors have been widely addressed by previous studies about the topic (Chase, 2010; Craig, 2014; Duran et al., 2014; Hyslop, 2010; Keathly and Akl, 2007; McMahon et al., 2004). This study confirmed the claims in previous literature regarding the positive impact of mentoring on the development of students' consideration of careers towards technology and choice of career aspiration beliefs towards professions that could possibly help other people within their community.

Lent et al. (2002) argued that school-to-work programmes which focus on the enhancement of skills – such as self-efficacy and/or outcome expectations – could be helpful in terms of facilitating the transition to the world of work. This study indicates that, within all the contexts where the case studies were developed, comprehensive facilitating mentoring was one of the main contributing factors to change the participants' beliefs about technology careers as a possible professional path.

8.2.2.4. Sub-question 4: What kinds of barriers and supports have been found during the study? How did they interact facilitating or hindering career interest?

In the SCCT, internal factors (e.g. gender, disabilities, ethnicity, etc.) and external factors (e.g. economic context, family, lack of infrastructure, etc.) are presented as potential influences on the development of career interest (Lent et al., 2002). This study aimed to investigate the presence of factors that could act as barriers or supports to such development and how they could potentially facilitate or hinder career interest.

For the past two decades, literature has been identifying and mapping how barriers can influence the development of interest towards STEM careers in order to understand how to bridge the gap between school and the world of work (e.g

Bernasconi, 2017; Craig, 2014; Cupp, 2015; Genoways, 2017; Hew et al., 2007; Nugent et al., 2015; Thackeray, 2016). Two major barriers which can hinder interest towards STEM have been mentioned in most of the studies: (1) the lack of STEM learning opportunities; and (2) the gender gap within the technology field (see Craig, 2014; Cupp, 2015; Genoways et al., 2017; Hew et al., 2007; Thackeray, 2016). The gender issue is related to cultural, historical and social factors which can explain the usual low number of secondary school female students pursuing an academic degree in STEM.

Since all educational settings where the three Case Studies took place offered several STEM learning opportunities, this study could corroborate the claims regarding barrier related to the gender issues. Craig (2014) argued that the low number of female professionals within the STEM field can be associated to individually and/or socially constructed stereotypes that hinder the choice for a STEM-related career path. Thackeray's (2016) findings revealed that, despite being aware of the social and historical barriers imposed to women within the STEM field, most of the young women participating in the study pursued or remained in the STEM field.

Findings indicated that the main factors of barriers within the educational settings investigated derived mainly from contextual influences and secondarily from internal barriers. The following contextual factors were found to have influenced the development of the participants' interest towards technology careers the most: (1) the lack of financial support from their families; (2) the lack of technology equipment to study at home; and (3) the pressure imposed by their families to quit their studies to contribute with the family budget. The following internal or personal barriers were found to have influenced the participants' career interest the most: (1) learning issues; (2) peer interaction issues; and (3) gender issues (mainly attached to stereotypes to which they had been exposed).

Although half of the students participating in this study were female, it was found that gender prejudice stemming from families and friends interfered and/or delayed the participation of female students in the ER groups (such as Donna and Sheila – Case Study 3 participants). Before having started to participate in the ER group, Donna and Sheila had to deal with their family expectations, learn robotics, programming and assembling robots. Donna and Sheila also had to wait longer than their

colleagues to become part of the programming or engineering teams, which seemed to have delayed their overall learning curve within the ER group. Reasons for that were previously explored (see Chapter 7). They include the lack of infrastructure to teach programming to a large group in the Case Study 3 educational setting, which limits the opportunities of learning programming throughout the year and the use of discovery learning as instructional methodology. The latter, combined with the fact that their teacher was not an expert in programming, seemed to have made new participants dependant on their more experienced peers, which, again, delayed the learning process, and, possibly, the development of interest towards technology careers. The Case Study 2 participants, who were all female, perceived the STEM field in Brazil to be dominated by male professionals and that might be an issue which could hinder their interest towards technology.

According to Lent et al. (2000; 2002), contextual supports and barriers can influence directly the development of career interest towards a certain subject. They argued that, even if one had already developed interest towards technology careers, factors such as lack of financial support or learning opportunities can hinder or even drive one to different career paths. Although all the participants in this study identified barriers to the development of their interest towards technology, it did not seem that such factors could make them deviate from the interests or choice goals which had been developed. However, such factors of barrier *could* influence changes in their career path – especially because of the underprivileged at-risk communities where the investigated educational settings were located. Such *ghost threats* can potentially *materialise* depending on the context in which everyone involved has been, thus, putting in danger the students' desire to pursue a career that could, eventually, help them to overcome their economic situation.

Findings also indicated that the main factors of support derived from two main sources: (1) the participants' families; and (2) the teachers or teaching teams coordinating each context. Such findings corroborated those presented in the existing literature, which indicated that personal and social landscapes have a major role in facilitating career interest. Bernasconi (2017) argued that factors such as having a resilient mindset (personal landscape) and positive peer interactions (social landscape) could facilitate development of career interest. Nugent et al. (2015) suggested that career consideration has a bigger chance to influence career interest than self-efficacy. In both cases, those who had already considered pursuing a

STEM-related career sustained their interest without having perceived their self-efficacy to take up such a profession. Nonetheless, Thackeray (2016) related the motivation to participate in STEM training to the joy and self-efficacy that developing certain activities can provide. Both career consideration (as a personal input, such as being self-motivated) *and* self-efficacy could lead one to develop career interest towards technology careers.

Michelle, a Case Study 2 participant, presented a high self-motivation and career consideration towards technology from the beginning of the investigation whereas the other participants seemed to develop career interests towards technology after developing self-efficacy towards either engineering, computing, or programming. This finding corroborates the SCCT proposition that interest stems from development of self-efficacy and/or outcome expectation beliefs (Lent et al., 2000, 2002). Barriers identified by the participants did not seem to have affected the development of their interest towards technology careers despite the potential of those barriers in doing it so, even though they may, in the longer term, seclude them from pursuing those interests.

8.2.2.5. Sub-question 5: Does the participation in Educational Robotics within educational settings play a role in young learners' development of a broader vision of the labour market?

Bridging the gap between schools and the world of work has been one of the challenges of educational systems concerned with the insufficient numbers of professionals within the STEM field worldwide (e.g. Munce and Fraser, 2012; Nugent et al., 2015). This investigation sought to understand a possible connection between participating in ER educational settings and the development of a broader vision regarding the technology labour market. Becoming familiar with the characteristics of the technology work market could be considered as an advantage for the participants and an influence in the development of their career interest (choice goals). Additionally, it could mean that the ER educational settings were successfully providing the students with substantial information about technology careers and, therefore, *increasing* participants' understanding of the technology field (Lent et al., 1994, 2002).

The students attending ER courses within educational settings providing learning opportunities involving activities related to the world of work were found to have had bigger chances to develop an increasing understanding about the labour market. The direct contact with experienced professionals working in the technology field was made available as learning opportunities – an approach that has been advocated by several researchers (e.g. Chase, 2010; Gandhi et al., 2016; Hyslop, 2010; McMahon et al., 2004). This investigation aimed to understand how such opportunities were made available through the ER curricula within the educational settings and the students' perceptions regarding their understanding of the labour market related to technology.

Most of the students at CESMAR, who participated in the Case Studies 1 and 2 claimed to have concluded their studies with a broader vision of the labour market. The curricula within CESMAR provided the students with opportunities to contact professionals working in the technology field and learning experiences aiming to enhance their understanding about the world of work related to technology. Furthermore, CESMAR was architecturally designed to be a space for sharing experiences where students could easily contact professionals from other courses. The only participants who were not found to have increased their knowledge about the technology labour market were those whose interest towards technology had not been developed. All the students participating in Case Study 1 claimed to have developed a better sense of what the technology labour market represented after having been part of the ER group for, at least, six months.

The Case Study 3 participants, in turn, did not claim to have their understanding of the technology labour market increased after having been part of the ER group for, at least, eighteen months. Such findings can be explained by two factors: (1) the lack of mentoring opportunities – which could have made it possible for the students to contact professionals in the technology field; and (2) the implementation of an *activity-based* ER curriculum (since 2007) – which only provided students with opportunities to increase their knowledge about the technology field during events (e.g. MOSTRATEC, science fairs, FLL, ER projects presentations, MNR, etc.). However, the Case Study 3 participants would usually be considered *the* persons with whom other students wanted to have contact, to consult when the subject was technology. As a result, those students would rarely have learning opportunities

during which they could increase their knowledge and/or to decide on their next steps within the technology field.

This section has summarised the findings which addressed the four subsidiary questions that guided this study. Such questions aimed to understand the factors informing the development of interest towards technology careers and technology skills. It has been established that the first subsidiary question, when revisited, led the findings to a different direction. Instead of indicating the most effective ER approach which had nurtured or hindered the participants' interest towards technology, it was found that one's personal interest in technology and the availability of multi-ER approaches had been more relevant factors to be considered in that behavioural process. Those factors seemed to have surpassed the need to designate differences between ER approaches and their strengths and weaknesses influencing the process. Findings also revealed that career consideration seemed to have been influenced by three factors: (1) a need to overcome one's socio-economic situation; (2) the perception of the teachers as role models; and (3) the future role that the participants wanted to play in society and, especially, in their community. It was found that the main sources of support in developing academic and career interest towards technology were the participants' families and teachers. In terms of barriers, the lack of financial support from the participants' families, the lack of equipment to develop technology skills, and the pressure exercised by families to contribute to the household budget played a major role in hindering interest towards technology. It has been established that the main factors contributing to nurturing a broader vision of the labour market were: (a) a curriculum aiming to provide a better understanding of the labour market; and (b) the direct contact with professionals with a background in technology.

8.3. Contributions

The main contributions to knowledge that can be attributed to this study are the following:

- This was the first study undertaken within Brazilian contexts of an in- depth investigation of an activity included in the implementation of full-time schooling promoted by changes in Education established in the laws of 2000;

- This is the first research to include a comprehensive study about the influence of ER approaches on career consideration and the perceptions on the world of work related to technology;
- Reviewed literature comprised mainly of cross-sectional studies usually based on surveys or mix-method approaches (see Chapter 2 for further details). This study is the first qualitative study to approach the phenomenon of career interest stemming from ER activities through a longitudinal multiple case study design;
- This is the first qualitative study in the ER field within Brazilian contexts to include the triangulation of the practitioners' (teachers, mentors and tutors) and students' viewpoints. This strategy generated rich data in order to confirm or refute the relationship between the participation in ER approaches and the development of interest or technology skills;
- This study confirmed findings from other studies which had indicated that teachers have been a fundamental factor in the development of interest towards STEM as a result the participation in ER approaches. Moreover, this study indicates that teachers played a major role in helping the students to develop self-efficacy beliefs and outcome expectations, as well as to overcome barriers;
- This study has contributed to the ER field by offering an in-depth view regarding the process of development of interest towards technology and skills in primary and secondary school students. By having understood the mechanisms that foster and nurture such interest, it was possible to add to the existing literature on ER, the impact of ER as a tool on attitudinal and learning changes within the Basic Education;
- This study reveals that most of the participants involved in the study developed interest towards technology careers as a result of their participation in multi-ER approaches curricula during an extended period (at least six months);
- This study indicates that the main factors contributing to the development of interest towards technology and technology skills included (a) the implemented curriculum within each educational setting; (b) the participants' level of education; and (c) the infrastructure available at each educational setting to develop the ER activities.

8.4. Implications and Recommendations

The implications for further research and recommendations for policymakers and ER practitioners presented in this section have been informed by the findings and the conclusions reached by this investigation.

8.4.1. Implications for further research

Amongst the implications for further research, the following must be emphasised:

- (1) Limited data about the impact of full-time schooling programmes: this study was inspired by the work that had been developed within several educational settings in Brazil which decided to implement ER in their full-time schooling curricula after the changes in educational laws promoted by the government in 2007. After more than a decade, during which many changes and developmental goals have been proposed (e.g. having at least half of Public Schools implementing full-time schooling), there is a limited number of studies about the impact of such changes. Furthermore, little evidence can be found regarding the implementation of ER curricula and changes in knowledge and attitudes towards STEM. Given the degree of confidence in technology that the participants in this study declared to have developed, it seemed that the impact of the ER curricula could have surpassed the expectations. The social impact of such ER programs to the students, especially the inclusiveness that they advance in order to promote the democratisation of the access to technology, has been emphasised by those participating in this study. The Brazilian government might benefit from large-scale studies about this topic, since more data could provide a broader understanding of the development of technology-related interest and skills;
- (2) Limited data confirming the benefits of ER approaches in career interest: developing an in-depth study of the ER approaches potentials shed a light on the factors influencing the development of interest towards technology and technology skills. However, educational systems in Brazil and ER manufacturers worldwide still claim that there is a direct connection between ER approaches and the development of interest towards STEM careers. Although this study's findings indicated that most of the participants had developed interest towards technology to a certain extent, more information

is needed better to understand this phenomenon. Thus, it appears that more longitudinal in-depth studies about ER groups, Fablabs, Coding groups and other educational settings implementing ER approaches could contribute to the clarification of this issue;

- (3) The influence of the families on the students' career interest: one of the strategies used to increase trustworthiness in the case studies developed for this research project was the triangulation of data which had been gathered through multiple methods and combined different viewpoints (Hamilton and Corbett-Whittier, 2014; Thomas, 2013). Although this study included the triangulation of the students', mentors/tutors' and teachers' perspectives, further research is necessary to understand the role of the students' families in nurturing or hindering their career interest. This study, for example, presented the students' perceptions of their parents/guardians/relatives' support; however, data originated from the families' accounts could be beneficial for the understanding of this phenomenon;
- (4) New longitudinal studies: this study investigated the impact of multi-ER approaches through middle to long-term periods (at least six months). The study helped to add more data to previous studies which had indicated that ER long-term activities have a bigger potential to impact knowledge whereas short-term activities impact on attitudinal changes (Nugent et al., 2010). Nonetheless, the debate about the different types of ER approaches and the role that the time of engagement plays in the process of development of interest could benefit from more data. The same seems to be valid for longer period studies, in which, ideally, young learners' career interest could be tracked for several years until they enter the workforce.

8.4.2. Recommendations for policymakers

- (1) Strategies to overcome barriers: this study's findings indicated several barriers to the implementation of full-time schooling within ER curricula. The barriers which were mentioned by participants (students, teachers, mentors/tutors) the most was the lack of institutional and/or personal infrastructure to practice the technology skills. For example, some participants who declared that they had become interested in programming because of the ER course could not practise, at home, the skills that they had

learned in class for not owning a computer. Some students would not be able to practise at school due to the limited resources and tools that those educational settings could provide. CESMAR, where case studies 1 and 2 were undertaken, had a strong supporting infrastructure to conduct their ER activities (including the support of the Federal Police who donated many legally-apprehended technology-related materials) whereas Beck School, where case study 3 took place, had to rely exclusively on the City Council. Moreover, due to budget adjustments, municipal support and/or funding depended on every elected Mayor's goodwill. Lego suggests that with one robotics kit, such as the Mindstorms, it is possible to develop activities with one to four learners (1:4 kit per students); however, within the investigated contexts, the ratio was usually 1:7 kit per students. Thus, it was difficult for some students to have the opportunity to learn how to programme with Lego Mindstorms. Beck School received, in 2016, five new Arduino robotics kits as an attempt to provide schools with more equipment. Nevertheless, the teacher did not receive enough training to learn how to use the new equipment and, therefore, the governmental initiative worked partially. This study recommends the development of long-term policies that surpass the four-year mayor tenure. Those plans could include strategies to solve issues with which the ER practitioners have been dealing for a long time (e.g. lack of equipment to conduct ER approaches, limited training provided to the teachers working with ER in Public schools);

- (2) Informality of the ER teacher post: although CESMAR relied on professionals within the technology field to act as ER teachers within the ER groups, Public schools (such as Beck School) usually do not (Leite and Ribeiro, 2012). In Brazil, public school teachers, who are hired through a municipal, state or federal public tendering, can only teach the disciplines related to their area of expertise and to which they have been qualified. Because ER is not a mandatory subject within the Public Basic Education curriculum in Brazil, there has been no selections for such position. Public schools usually invite a schoolteacher who is already part of the faculty to implement ER activities in the school full-time curriculum after having received governmental permission (from the City Council, the State or Federal Government). Amongst the many challenges that such practice can impose, having an ER teacher whose expertise is not within the ER field might be the toughest. The

issue seems to be particularly pertinent, since the number of public ER teachers and communities supporting the ER classes have been increasing in Brazil (Paula, 2017);

- (3) Recognising ER as part of the curriculum: as previously discussed, long-term policies could be beneficial to both institutions and students interested in ER. This study's findings evidenced the difference between the implementation of ER as part-time and full-time schooling curriculum in primary and secondary schools. Secondary school institutions, such as CESMAR, can rely on laws (e.g. PME) that recognise ER as a subject within the curriculum. However, primary schools in Brazil must develop their curricula based on the PCNs which, despite promoting the inclusion of ICTs in classroom, do not recognise ER as a subject on its own. This study suggests a review of the curriculum guidelines in which disciplines, such as ER, are included as part of the curriculum in order to facilitate the implementation and/or advancement of such digital educational technologies within the public education system.

8.4.3. Recommendations for practitioners

- (1) Improvements in ER approaches: this study's findings indicated that each ER approach (classes, projects and competitions) presents advantages and disadvantages. The biggest advantage of implementing a multi-ER-approach curriculum was found to be related to the fact that students can become interested in or focused on just one ER approach. However, if the educational settings provide the students with opportunities to work with only one ER approach, the students might leave the ER groups due to the lack of interest. For example, a school could focus exclusively on competitions but the students who prefer ER projects could feel demotivated. Within this study, several participants claimed to have felt affected by certain characteristics of the ER competitions (e.g. lack of time to become prepared for the FFL). For that reason, ER practitioners should consider feedback from the students to improve and/or adjust the selected ER approaches. The types of skills that the ER practitioners aim to promote and/or want the students to develop could be used to inform the advantages and disadvantages of each ER approach. The OBR, for example, is a competition that has barely changed for the last eight years. Teams must develop a *line-following robot* that would simulate rescue missions (e.g. rescuing survivors of a specific

disaster). The main advantage of these competitions is that the teams need less time to become prepared, since the challenge does not change significantly from one year to another;

(2)Multi-ER-approaches curricula and the development of technology skills: the educational setting where the three case studies were undertaken had implemented multi-ER-approaches curricula. Beck School relied on an activity-based curriculum, that means, although all ER approaches were applied during the year, the technology skills developed were limited by the type of activity on which the ER team had to be focused. Furthermore, the Case Study 3 participants could not develop technology skills outside the ER approaches being applied. For example, from the beginning of the year until April, the Case Study 3 participants focused on ER classes. They learned (or reviewed) the basics of Robotics (e.g. programming the Mindstorms kits, assembling robot cars). From April on, however, the ER group focused on the first ER challenge (OBR) and the first ER project (MNR). As a result, the opportunities for learning skills, such as programming with S4A, would become immediately limited due to the requirements of the following activity and the lack of infrastructure and robotics kits. At CESMAR, in turn, where the ER curriculum was based on the development of technology skills, the three ER approaches were used as a means through which the students could practise and perform the aimed skills (e.g. programming, teamwork, engineering). Consequently, the goal set out within the curriculum was related to skill development. This thesis recommends that primary schools should start the school year with an initial curriculum, rather than developing it according to the activity's requirements. Such curriculum should be flexible enough to be adjusted according to the particularities of each context (e.g. students' needs, infrastructure within the educational setting);

(3)Facilitating the path to technology-related careers: in countries such as the U.S.A., secondary school students can count on institutional/governmental programmes, teachers/councillors and/or courses to help them with their career decisions (Brown, 2002; Vondracek et al., 2014). Brazilian secondary schools can rarely offer the same service, which leaves an immense gap between the school and the students' career interests. The educational settings where this study took place seemed to offer their students with support that enable them to broaden their understanding of the job market and the technology careers. At CESMAR, for

example, the ER curriculum aimed to increase the students' knowledge about technology which could guide the students towards such careers. This thesis recommends to ER practitioners to use the ER groups, within the educational settings, to motivate the participation of the students in events which provide the possibility of contacting professionals in technology-related field. For example, the FLL, in the U.K., provides, alongside the ER challenge, lectures with STEM professionals and a celebration of STEM knowledge. By allowing the students to understand the scope of technology-related careers, the educational settings, through the ER activities, could start bridging the gap between the Basic Education levels and the world of work;

- (4)Programming languages in English – an issue for underprivileged learners in Brazil: as previously discussed in Chapter 6, the Case Study 2 participants had been given programming handbooks (about the C, S4A, and Mindstorms languages). Although the handbooks had been written in Portuguese, the participants claimed to have had several difficulties to understand the programming logic. Amongst the reasons for such difficulties, the fact that the programming languages are usually written in English was widely emphasised. Since the teachers usually did not allow the students to use the internet for translation purposes during the classes, the participants felt that they would have to spend a lot of time to understand another language. It is understandable that language became a barrier that needed to be overcome at some point during the ER course. As a recommendation from this thesis, strategies to undermine the students' language issue should be taken. For the Case Study 2 participants, for example, such issue could have been avoided if the students had the teacher's permission to access the internet as a translation tool while learning how to programme. The Case Study 3 participants, for example, used one of their ER projects, the 'Clean World', to encourage students to translate all the games they had developed to English and Spanish, the main foreign languages taught within Brazilian public primary schools.

8.5. Limitations of the study and possibilities for further research

This section outlines the following limitations and possibilities for further research:

- There is limited evidence about the impact of ER on academic and career interest towards technology worldwide (e.g. Craig, 2014; Duran et al., 2014; Nugent et al., 2014). In Brazil, that evidence was found to be especially limited and mainly based on the result of short-term activities – which are more likely to influence *attitude* towards STEM than *knowledge* (e.g. Garcia et al., 2012; Magalhaes et al., 2015; Nunes et al., 2014). Consequently, there has not been national studies to compare to this investigation in terms of sampling and curriculum used by educational settings;
- Reviewed literature for this study indicated that (a) the macro-economic context has been suffering with the lack of technology professionals; and (b) ER could be a valuable educational tool to help solving such issue. Further research could address how the implementation of ER curricula in schools can help bridging the gap between schools and the world of work;
- Sampling included in this research stemmed from two educational settings within underprivileged urban neighbourhoods in the capital of the Brazilian Southern State. Thus, this was a small-scale study in terms of sampling. Further research could focus on other areas, including those with different levels of socio-economic development (e.g. young learners from private primary and secondary schools, students in rural areas);
- Educational settings developing multi-ER-approaches in São Paulo were also invited to participate in this study, since, alongside Rio Grande do Sul, São Paulo was the only Brazilian state where full-time schooling with ER approaches had been implemented. However, access to teachers were controlled by their supervisors/headmasters who, acting as gatekeepers, made demands (e.g. the physical presence of the researcher during multiple stages of the study) which were impossible to be met due to the researcher's constraints in terms of resources. Such issue can be solved if the study is developed by a team from which, at least, one member could be *in situ* to deal with gatekeepers;
- The study was conducted with primary and secondary School students; further investigations could involve undergraduate students, for example, and explore the connections between engaging in ER approaches and develop undergraduate studies in a technology-related field. Participants in groups such as Fablabs or Coding could be sampled for studies that aim to investigate the impact of multi-ER approaches developed in off-school

grounds – which are not usually included in ER research (Athanasίου et al., 2017);

- This study used a qualitative approach to understand the development of career interest through time and with an in-depth approach. Changes in the research questions could help the development of quantitative or mixed-methods studies about the same topic. For example, a study involving a mix of pre- and post-surveys, coupled with follow-up interviews, could enable the use of a bigger sample and, consequently, generate more statistical data about this phenomenon;
- This study investigated which ER approaches (ER classes, projects and competitions) developed within the context of implementation of full-time education had been more successful in nurturing interest towards technology careers. Comparisons between activities were conducted across case studies rather than with control groups because of the limited number of groups in the same region offering similar learning opportunities within similar conditions. Further research could address such issue by comparing groups in which ER approaches are developed to groups in which ER approaches are not developed in order to bring new data about the impact of ER approaches towards technology skills and career interest;
- This study was conducted in the Brazilian educational context. Comparative studies using a similar methodology could shed a light on the factors that underpin the development of interest towards technology stemming from ER approaches, highlighting the differences and affinities of such contexts and that in Brazil.

8.6 Conclusion

The main contribution of this study is the investigation of the development of interest towards technology careers in Brazilian primary and secondary school students. This study has combined triangulation of data and points of view in a case-study research design within two educational settings involving three ER classes and 16 students From Primary and Secondary School. Comparisons were made within and across case studies considering demographics, participants' education levels and curriculum being developed in the educational settings.

The main finding of this study is that the majority (fourteen of sixteen) of the participants developed interest towards technology to the extent that they developed career-related and/or academic-related goals as a result of their participation in ER classes, projects and/or competitions (see chapters 5, 6 and 7). The ER approaches which were found to be the most successful in nurturing or hindering interest towards technology varied according to personal interests of each participant. Academic and career interest towards technology was related directly to positive self-efficacy and outcome expectations beliefs developed during this study – which confirmed the propositions in SCCT. Barriers were found to be the main factors that mediate the development of interest towards technology careers in primary and secondary school students. Those findings generated recommendations for those involved in ER (policymakers and practitioners) as well as implications and possibilities for future research which could help to improve the implementation of ER as an educational tool in Basic Education.

The development of interest towards technology careers and technology skills seem to be a product of long-term participation in ER activities. Other sub-products include (a) career consideration; and (b) a broader view of the technology labour market – which can help nurturing interest and bridging the gap between school and the world of work. Despite not presenting a definitive response for the question “what inspires young people towards the technology field?”, this study findings evidenced connections between the participation in ER learning experiences and the development of academic and career interest towards technology.

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APPENDIX I



CAREER INTEREST AFTER EDUCATIONAL ROBOTICS CHALLENGES PROJECT

You have been invited to take part in a research study to be interviewed about career interest and educational robotics.

What is the project about?

Participating in a robotics after-school group gives you a chance to work with new technology which you wouldn't normally use at school. It's also a way to work closely with other children on a long project. We are interested to learn more about children's experiences at your educational robotics group so we would like to listen to your thoughts.

What will I be doing?

A researcher from The University of Edinburgh will meet your robotics group and your head teacher at your school in one or two of your sessions. Some children may be asked to participate in a group discussion with their classmates, a researcher from The University of Edinburgh and your robotics teacher. In order to provide some supplementary information, a new contact with the researcher might be made in December/2015.

If you have any questions, please ask the researcher. If you do not want to take part of it that is ok. If you want to stop part way through the session, that is also fine. Tell your teacher and he or she will give you something else to do.

I do/do NOT give consent to take part in the study.

Name:

School:

Class:

The University of Edinburgh
October-November 2015

Dear Parent or Guardian

Invitation to participate in research

At October-November/2015, your child's educational robotics group is taking part in a research study in which they will give their accounts on how the learning experiences in their robotics class may help them to develop career interest in technology.

We know that educational robotics are an opportunity to young students to be involved in hands-on activities, which can broaden their view about careers. My research will further explore this link between participation in educational robotics groups and career interest in secondary students over an extended period.

What will it involve?

Interviews with your child will be held in his/her school, during a period of two weeks between 26/10/2015 to 06/11/2015. On the day of the interview a researcher from the University of Edinburgh will invite the student to discuss (in groups and individually) the career interest topic. This discussion will be recorded to enable us to remember the key points later.

I will be asking parents to participate in an interview also. During this session, I will interview you about your perceptions about career interest developed (or not) by your daughter/son. This interview will be recorded in order to enable us to remember key points later.

Your participation in this research is voluntary. If you choose not to participate, no questions will be asked and there will, of course, be no consequences for your child.

I will not be sharing the personal information I receive from you with anyone, even school staff, and the information I collect from my research project will be kept private. Any information about your interview session will have a number on it instead of your name. Each participant will receive a summary of the results after my write-up.

If you would like to take part in my project, please complete the tear-off slip below and return it with your daughter/son to give to their teacher.

Many thanks

Eder Coelho Paula

PhD student in Education

Name of child

Name of Teacher

Your name (parent/guardian)

I do/ do not give permission for my child to take part in the research project.

I would like to be involved in your research project. Yes/No

If Yes: Please contact me in the following way for further details (tick as many boxes as apply)

☐ phone me on

☐ text me on

☐ email me on

I understand that my participation in this project is voluntary and that I may withdraw at any time.

Signed _____

The University of Edinburgh

17th October 2014

TEACHER PARTICIPANT CONSENT FORM

Invitation to participate in research

At October-November 2014, you and your educational robotics group students will be asked to take part in a research study in which they will give their accounts on how educational robotics learning experiences may help them to develop career interest in technology.

Title of the Project and Study Background

Title: *Learning experiences developed in Brazilian educational robotics settings and their impact on interest for technology careers and technology skills in Primary and Secondary students*

We know that educational robotics are an opportunity to young students to be involved in hands-on activities, which can broaden their view about careers. My research will further explore this link between participation in educational robotics groups and career interest in secondary students over an extended period.

What will it involve?

Interviews with you and your students will be held in your school, between 06/10/2015 to 06/11/2015. On the day of the interview a researcher from the University of Edinburgh will invite the students to discuss (in groups and individually) the career interest topic. This discussion will be recorded to enable us to remember the key points later. Individual interviews with each student should not take more than 30-40 minutes.

I will be asking teachers to participate in an interview session as well. During this session, I will interview you about your perceptions about career interest developed (or not) by each of your students who agreed to participate on this study and your perceptions about the development of career interest. This interview will be recorded in order to enable us to remember key points later.

Your participation in this research is voluntary. If you choose not to participate, no questions will be asked and there will, of course, be no consequences for your students.

I will not be sharing the personal information I receive from you with anyone, even school staff, and the information I collect from my research project will be kept private. Any information about your interview session will have a number on it instead of your name. Each participant will receive a summary of the results after my write-up.

Contacts

If you have any questions regarding this research, please contact Eder Coelho Paula at s1269628@sms.ed.ac.uk

If you would like to take part in my project, please complete the tear-off slip below and keep it with your students/parents to return to us.

Many thanks

Eder Coelho Paula

PhD student in Education

Name of Teacher

I would like to be involved in your research project. Yes/No

If Yes: Please contact me in the following way for further details (tick as many boxes as apply)

☐ phone me on

☐ text me on

☐ email me on

I understand that my participation in this project is voluntary and that I may withdraw at any time.

Signed

APPENDIX II

SOCIO-EDUCATIONAL COURSE CURRICULUM

PROJECT: CESMAR

COURSE: Informatics focused in Robotics

MAIN COORDINATOR: ---

1. Course program: In Informatics/Robotics, we will seek the personal and professional qualification of the students in this field approaching diverse topics from Portuguese and History to Basic Fundamentals of Informatics (hardware and software). We will, then address more complex topics such as Electronics, Logics, open-source software and open-source robotics.
2. Objectives: The availability of educational opportunities (mainly in ICT and robotics) for young learners from at-risk backgrounds or socially vulnerable.
3. Learning and teaching methodologies: Learning in this course must be seen as a process to be constructed, a path to be walked, where research, study, and discipline are fundamentals to the success of our objectives. The methods used in order to achieve such goals include, but are not limited to: instructional classes, lectures, hands-on activities, simulations of real-world situations, individual and group discussions, and several types of research.
4. Topics of Study:
 - History of Informatics
 - How a computer works
 - Hardware
 - Dual Boot installation
 - Introduction to Linux
 - Introduction to Windows
 - Installation of plug-ins and drivers
 - Alphanumeric keyboard
 - Email
 - Social Media
 - Internet research
 - Office platforms
 - Command Terminal
 - Wine
 - Electronics (electricity, current, capacitation, resistors, diodes, transistors, motors, residential automation)
 - Micro-controllers (Lego, Arduino, Raspberry Pi)
 - Programming Logics
 - Creation and presentation of Open-source robotics projects and/or software
5. Evaluation of Student's performance: The assessment of the performance of the students will be conducted monthly by teachers and the pedagogical support team through different types of instruments, such as tests, developments of papers, presentations and others.

APPENDIX III

ELECTRO-ELECTRONICS COURSE CURRICULUM

PROJECT: CESMAR

COURSE: ELECTRO-ELECTRONICS

MAIN COORDINATOR: ---

1. Course program: To provide students with basic and expanded notions of electronics and electricians in a way that they will become able to provide electro-electronics service maintenance for the industry in the end of the course.
2. Objectives: To qualify personally and professionally young learners to work in the electricians, electronics, automation, and robotics fields through a comprehensive curriculum in order to promote better social conditions and inclusion in the world of work.
3. Specific objectives: To learn how to build, test and inspect motherboards, devices, and/or electronic devices. Learn how to install control panels of industry devices. Learn how to organize and keep a workstation.
4. Learning and teaching methodologies: Learning in this course must be seen as a process to be constructed, a path to be walked, where research, study, and discipline are fundamentals to the success of our objectives. The methods used in order to achieve such goals include, but are not limited to: instructional classes, lectures, hands-on activities, simulations of real-world situations, individual and group discussions, and several types of research.
5. Topics of Study In Automation and Robotics
 - Capacitors
 - Transformers and coils
 - Protoboards
 - Automation
 - Technical design
 - Computer maintenance
 - Installation and administration of network systems
 - Electricity
 - Resistors
 - Diodes
 - Transistors
 - Micro-controllers
 - Development of robotics projects
 - Electric Motors
 - Relays
 - Programming Logics
 - Commercial and residential automation
 - Automation to promote social inclusion
 - Integrated Circuits
 - C Programming Language
6. Theoretical Disciplines:
 - Workers' rights
 - Youth and the involvement in social issues
 - Instrumental Mathematics
 - Instrumental Portuguese
 - History of Electronics and Informatics
7. Evaluation of Student's performance: The assessment of the performance of the students will be conducted monthly by teachers and the pedagogical support team through different types of instruments, such as tests, developments of papers, presentations and others.